# Installation Guidelines

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Section 19

**In this Section:**

# Generic and Copper

## Planning

Before you start, prepare to start.

- Have you got the cabling system design mapped onto the layout of the space?
- Do you have the correct materials ordered against the Bill Of Materials estimated to complete the project?
- In regards to the CPR, (Construction Products Regulation) have you ordered the correct Euroclass of cable as specified by the client. If in doubt please reference Section 2 for more details.
- Has the fire stop solution been approved?
- Do you need any specialist training or product support from Excel?
- Are the deliveries scheduled to match the installation plan?
- Are there any site inductions required? If so, when are these held?
- Is the area to be handed over to you for your installation? If so, in what condition? Will you be required to run a 'Permit to Work' scheme for you and other trades?
- Is there a clean, dry, secure storage area allocated for your materials?
- Are there any special precautions to observe for site Health and Safety?
- Are the method statements and COSH statements for the installation, termination and testing approved?
- Do you have a change control process and reporting scheme?
- Do you need to notify the site with the names or identification for your staff?
- Is the labelling method, scheme, style, colour agreed and approved by the client?
- Is the test equipment serviceable and to specification?
- Is there a headroom performance requirement from the tested cabling?
- Have you agreed how to deal with a star pass, (ie. marginal results)
- Do you have access to power outlets for testers, laptops etc?


## On site

- Is the containment installed in the correct place and to the right specification?
- Are you holding daily briefings for the site operatives?
- Is there any temporary fire stopping required during the installation phase?
- Is there any difference between the reality of the site and the plans?
- Are there any access restrictions or other trades working in the same areas at the same time?
- Is the earthing and electrical system installed?
- Is there restriction on the use of mobile phones or walkie-talkies?

# Site Environment Classification

The environments where cabling is to be installed are classified to cover the different conditions under which the cabling is required to operate. Conditions which may affect the cabling performance are used to determine the applicable environmental classification. Use the environmental classification to select the components. The same classification is used to determine the appropriate containment and installation techniques.

The local environment along the channel is classified for each M, I, C, or E group, and the classification of an environment is determined by the most demanding parameter within the M, I, C or E group. With regard to temperature, the local environment is considered to be the operating temperature of the cabling.

The considerations for:

- Mechanical rating include shock/bump, vibration, crush, impact, bending, flexing and torsion
- Ingress rating include particulate ingress, immersion
- Climatic and Chemical rating include humidity, rate of change of temperature, solar radiation, damaging chemical concentration
- Electromagnetic rating include electrostatic discharge, conducted radio frequency, magnetic field

All twisted pair copper cabling supplied by Excel for normal indoor use is designed and classified to perform in a Class 1 environment ($M_1$, $I_1$, $C_1$, $E_1$). Most indoor office and data centre environments fall within the Class 1 environment ($M_1$, $I_1$, $C_1$, $E_1$).

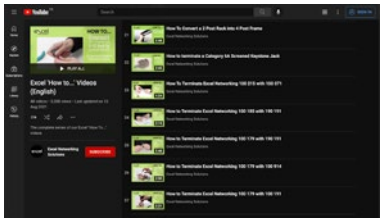
If you have a specification requirement which is beyond Class 1 use you must consult with Excel technical support for guidance on containment and product selection.

# Excel 'How To' Video Clips

Our series of 'How To' video clips demonstrate the recommended and most efficient methods of installation of various products from across the Excel range. This information can be of particular use for engineers or designers, new to Excel, or to products such as screened Category $6_A$. The clips can be viewed via **Youtube**, or by visiting **www.excel-networking.com**

We will be adding to the series over time, so please check the Excel website for the latest updates.

Head over to our How To video playlist on youtube



UPDATED for V5

# Containment and Cable Routing

## Power and Data Separation

Local and national safety regulations may require different separation or segregation distances. Separation and segregation for safety must take precedence over all other requirements. To reduce the risk of noise disturbing the data flowing in copper twisted pair cables, Excel recommends following the requirements set out in the latest issue of EN50174; these are summarised below. The more stringent requirement (greater distance) shall take precedence.

Essentially there are two ways of mitigating the effects of noise disturbing the transmission of data in a copper twisted pair cable; one way is to separate by distance the twisted pair cabling from the noise source, using air to attenuate any noise; the other way is to provide a barrier between the noise source and the twisted pair cabling using a grounded barrier to attenuate the noise.

The factors to consider are:

- Environment
- Type of containment
- Performance of cable type
- Application being supported
- Construction of power cable
- Scale of power source
- Proximity to the power cable

When all of this is calculated you get a separation recommendation.

**Environment:** All twisted pair copper cabling supplied by Excel for normal indoor use is designed and classified to perform in a Class 1 environment $M_1$, $I_1$, $C_1$, $E_1$.

**Containment:** No barrier or no metallic barrier (typically wall trunking or open ladder), open metallic (typically basket but not ladder), perforated metallic (typically slotted tray) and solid metallic (typically 1.5mm wall steel conduit).

**Cable Style:** The performance of the cable and connector set is provided by the manufacturer. The applications to be supported will be the determination factor that provides the Classification for the cabling system chosen.

**Power Cable:** An assumption is made that power cables will provide a high degree of self cancellation for any noise carried if they are constructed with a live, neutral and earth bound together in a common sheath. If individual tails are used (separate unbound conductors) then power cable is to be treated as a noise hazard.

**Power Scale:** How many power cables are present or likely to be installed? Classification for power cabling is based on the qualification of a single phase 230 Volt, 20 Amp circuit. Three phase power is to be treated as three times a single phase. For circuits which are more than 20A treat as multiples of 20A. Lower voltage AC or DC power cables must be treated on their current rating, e.g. a 100A 50V DC cable is equivalent to 5 of 20A cables.

$$A = S \times P$$

**A** (Final Separation Distance) = **S** (Basic Separation Distance) x **P** (Power Cabling Factor)

# S - Basic Separation Distance

| | | Cable Management System | | | |
|---|---|---|---|---|---|
| Segregation Classification | Cable Performance | None (or Non-metallic | Open metallic containment | Perforated metallic containment | Solid metallic containment |
| d | Class $F_A$ | 10 mm | 8 mm | 5 mm | 0 mm |
| c | Class D or E or $E_A$ F/UTP | 50 mm | 38 mm | 25 mm | 0 mm |
| b | Class D or E or $E_A$ U/UTP | 100 mm | 75 mm | 50 mm | 0 mm |
| a | Coaxial | 300 mm | 225 mm | 150 mm | 0 mm |

| Notes | | | | |
|---|---|---|---|---|
| | Plastic containment | Equivalent to weld mesh 50 mm x 100 mm and steel tray of less than 1 mm thickness (and trunking without lid) | Equivalent to steel tray of 1 mm thickness (and trunking without lid).<br>Cables to be installed at least 10 mm below top of barrier. | Equivalent to steel conduit 1.5mm wall thickness. Steel conduit less than 1.5mm thickness will require greater separation. |

# P - Power Cabling Factor

| Quantity of Circuits | P – Power cabling factor |
|---|---|
| 1 to 3 | 0.2 |
| 4 to 6 | 0.4 |
| 7 to 9 | 0.6 |
| 10 to 12 | 0.8 |
| 13 to 15 | 1.0 |
| 16 to 30 | 2.0 |
| 31 to 45 | 3.0 |
| 46 to 60 | 4.0 |
| 61 to 75 | 5.0 |
| > 75 | 6.0 |

## Zero Segregation - Conditional Relaxation of Requirement

Where the requirements in specific EMI conditions do not apply, no segregation distance is required between power and data where:

Power - Single Phase, Total power ≤ 32A, Power conductors contained in overall sheath or twisted, taped, bundled together

Data Cable - Segregation Classification is "b", "c" or "d" in an $E_1$ environment classification of EN 50173

## Separation requirements for specific EMI sources

| Source of disturbance | Minimum separation | Note |
|---|---|---|
| Fluorescent lamps | 130mm | a |
| Neon lamps | 130mm | a |
| Mercury vapour lamps | 130mm | a |
| High-intensity discharge lamps | 130mm | a |
| Arc welders | 800mm | a |
| Frequency induction heating | 1000mm | a |
| Hospital equipment | | b |
| Radio transmitter | | b |
| Television transmitter | | b |
| Radar | | b |

## NOTE

a The minimum separations may be reduced provided that appropriate cable management systems are used or product suppliers guarantees are provided

b Where product suppliers guarantees do not exist, analysis shall be performed regarding possible disturbances e.g. frequency range, harmonics, transients, bursts, transmitted power, etc.

c. Cables used for applications such and BMS and access control are deemed to be 'Control Cables' and not classified as power cables and do not require separation.

UPDATED for V5

# Overhead and Under Floor Containment Fill Ratio

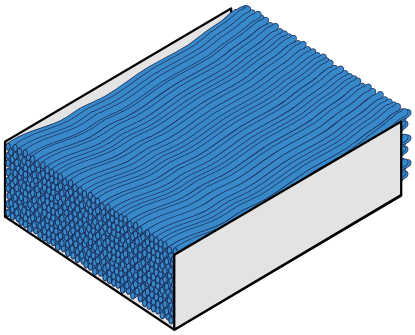
Cable trays, basket, ladder racking and other containment should be filled on day one:

- To accommodate a day one minimum calculated spare fill of 20%
- Up to a maximum of 150mm (6 in) cable depth for solid floor containment.

The spare capacity requirement is to allow room for future expansion, and to facilitate additions and removal of cables once the building becomes operational

NOTE: A calculated fill ratio of 50% will physically fill the entire containment due to spaces between cables, and random placement.

Picture shows a cable tray that is full of cable which equals a 50% fill ratio



Example - What is the minimum width of a 75mm deep cable tray supporting 1000 cables, each with a diameter of 5.5mm?

$$\text{Area of one cable} = \frac{(\text{cable diameter})2 \times \pi}{4}$$

$$\text{Area of one cable} = \frac{(5.5)2 \times 3.14}{4} = 23.75\text{mm}^2$$

$$\text{Area of 1000 cable} = \frac{(5.5)2 \times 3.14)}{4} \times 1000 = 23746\text{mm}^2$$

Multiply this occupied area by 1.2 to give 20% over size for day two expansion

$$\text{Usable Area or Area required within cable tray (50\% fill)} = \frac{\text{cable tray width x cable tray depth}}{2}$$

$$1000 \text{ cables} = (23746\text{mm2}) \times 1.2 = \frac{\text{cable tray width x 75mm}}{2}$$

Minimum width of cable tray = 759.9mm

# Excel Cable - Containment Size Calculations

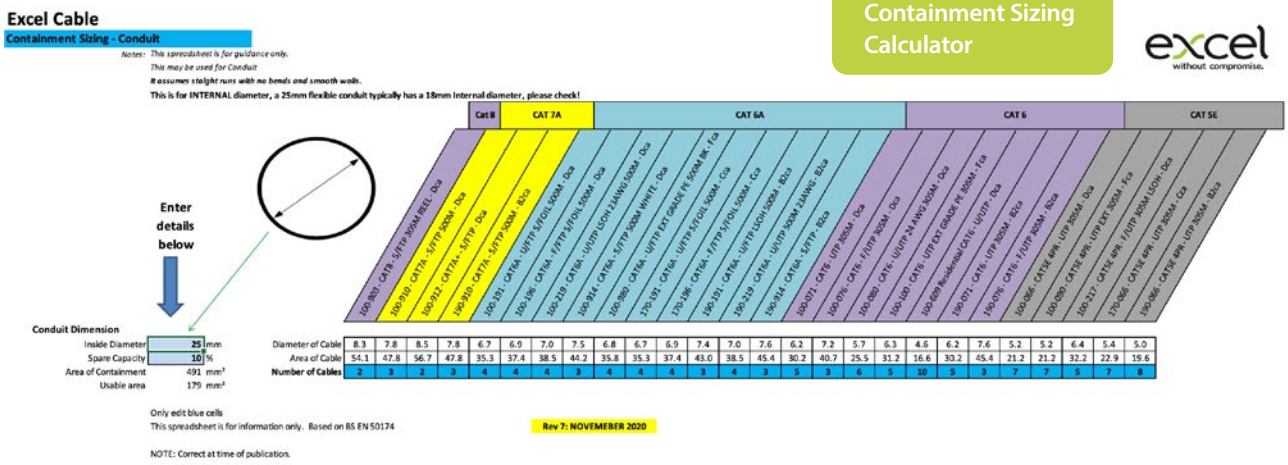
Containment sizes may be calculated based on the: dimensions of the containment, diameter of the cable and fill ratios.

Different styles of containment use different formulae to calculate the maximum number of cables that may be housed. These formulae offer an estimate of the quantities. However, the actual quantity of cables that may be contained will be influenced by other factors such as routing, access, etc. Never plan to fill containment to the maximum during the initial installation as quantities are likely to change as additions are required.

Excel offers a spreadsheet that is available for download from the Technical Note section of the Excel website's Partner Area.

(all dimensions in mm)

**Use our Excel Containment Sizing Calculator**




$$Area\ of\ cable = \frac{\pi d^2}{4}$$

Cross-sectional area of an individual cable is calculated –

(where d = diameter of the cable)

## Tray Calculation

This tray calculation is based on the information in EN 50174-2:2009 + A1:2011

$$Maximum\ number\ of\ cables = \frac{wh}{2 \times Area\ of\ cable}$$

(where w = width and h = height of the tray)

(in the above calculation the area of a cable is doubled to allow for the fact that a cable is circular and also will not fit perfectly in containment).

These formulae may be combined into one

$$Maximum\ number\ of\ cables = \frac{2wh}{\pi d^2}$$

Note – the maximum stack height of cables is 150 mm

The number of cables should then be reduced to allow for future installations.

### Basket Tray or Ladder

As basket tray and ladder is non-continuous containment the maximum stack height needs to be reduced. This calculation is based on the information in EN 50174-2:2009 + A1:2011

$$Maximum\ stack\ height = \frac{150}{1 + 0.0007\,s}$$

(where "s" is the span distance)

### Conduit

The formulae for the maximum number of cables within conduit is based on a calculation that has been modified from the BICSI Telecommunications Distribution Methods Manual (TDMM).

The formula assumes straight runs with no bends and smooth walls.

$$Maximum\ number\ of\ cables = 0.4\,\frac{c^2}{d^2} - 1$$

(where "c" is the inside diameter of the conduit and "d" is the diameter of the cable)

The number of cables should then be reduced to allow for future installations.

## Heating Effects

Energy losses from within cabling will be translated into generation of heat. There are many factors which accumulate to create this effect. The installer needs to be aware that the temperature rise in the cabling at these points can be in the order of 10°C or higher when all of these factors come together. The temperature rise created is greatest where:

- the cabling is managed into large bundles
- and/or there are a large number of simultaneous users
- and/or cabling is run into constricted spaces such as at wall penetrations
- and/or the cabling is required to support higher energy applications / PoE applications
- The energy loss due to heating effects is different for Screened and Unscreened cable

All the performance criteria for the 100m Channel as outlined in EN 50173-2 is based upon it operating at an ambient temperature of 20˚C and for every degree over this level this distance will be reduced. The following formula provided in the above standard gives the rate of reduction for unscreened cables, in short for temperature increases up to 20˚C above the ambient the Channel should be reduced by 0.4% and for temperatures increased over 40˚C above the ambient there is an additional 0.6% that has to be added.

| Unscreened |
|---|
| $L_{t>20^{\circ}C}=L/(1 + (T-20)\ x\ 0{,}004)$ |
| $L_{t>40^{\circ}C}=L/(1 + (T-20)\ x\ 0{,}004 + (T-40)\ x\ 0.006)$ |

This could potentially have a dramatic effect to the performance of installed cabling as recent research shows that the level of heating can be significant in some cases 30-40˚C above the ambient.

Screened Cabling performs much better, as the research has proved it does not heat up as much as an unscreened cable and when it does the de-rating formula is much simpler as it is based upon 0.2%.

| Screened |
|---|
| $L_{t>20^{\circ}C}=L/(1 + (T-20)\ *0{,}002)$ |

L = Length T = Temperature

These heating effects can be mitigated by:

- reducing the bundle size
- loosening the bundle ties at points of constriction
- distributing the high energy use across different cable bundles

The latest addition of BS EN 50174-2 provides additional guidance on separating bundles and the use of air gaps between them.

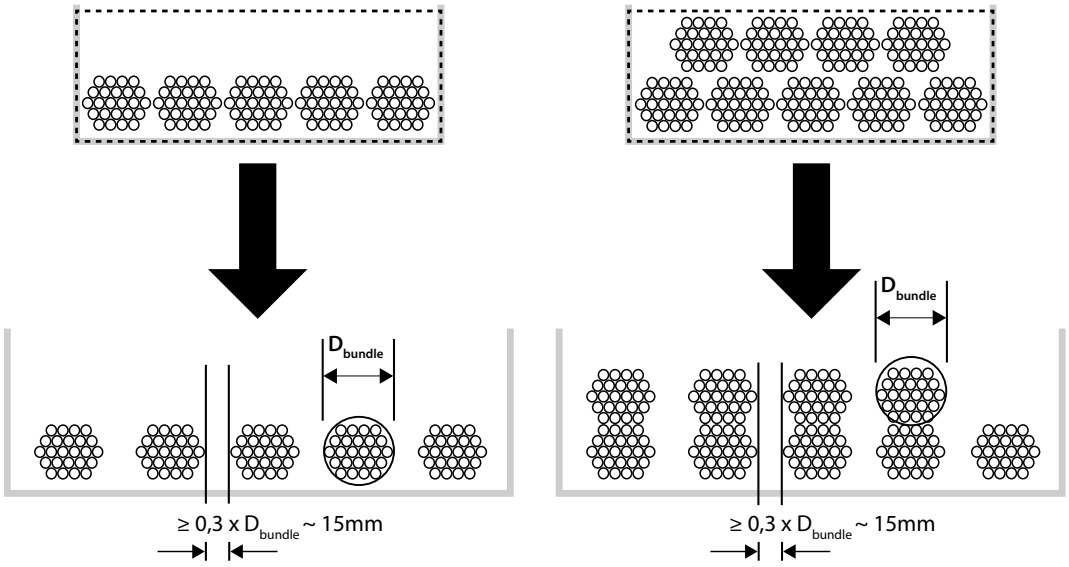
UPDATED for V5

### 6.4 Separation of cable bundles to reduce thermal impact of remote powering

Groups of cable bundles subject to remote powering produce higher temperature rises since the centre cables are essentially unventilated.

The following recommendations apply to groups of bundles of lengths in excess of 1 m. Shorter constructions (e.g. within fire barriers) are known to cool axially.

To minimise the heating within groups of single rows of bundles of balanced cables (containing up to 24 4-pair balanced cables in accordance with 5.3.5.3.1), the cable bundles should be separated by vertical "chimneys" allowing each bundle to cool by convection. Figure 12 a) shows this in a schematic form. A "chimney" width of 0,3 x bundle diameter (Dbundle) has been shown to provide adequate cooling such that each bundle behaves as a single, isolated, bundle in the applicable installation condition.




b) multiple rows of bundles

**Figure 12 — Separation of cable bundles to minimize heating**

To reduce the heating within multiple rows of bundles of balanced cables (containing up to 24 4-pair

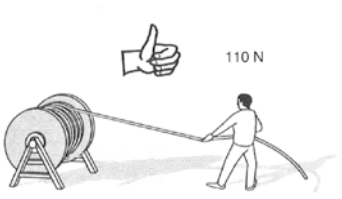
balanced cables in accordance with 5.3.5.3.1), the cable bundles should be separated by vertical "chimneys" allowing each bundle to cool by convection. However, a "chimney" width of 0,3 x bundle diameter (Dbundle) as shown in Figure 12 b) only provides limited mitigation and the temperature rise in a bundle should be assumed to be twice that of a single, isolated, bundle in the applicable installation condition.

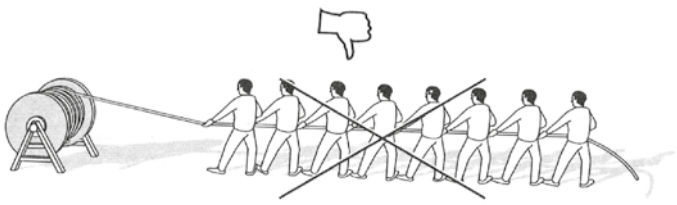
Other guidance is given in Tech Note TN08 which is located within the 'Partner Area' of www.excel-networking.com

# Cable Installation

From the cabling system design and floor plans, make a cable pulling schedule. Map the pulling schedule onto the floor plans

- Identify the labels and cable ID so that temporary labelling can be applied
- It may be faster, cheaper and more accurate to print two sets of the final cable labels, using one set for installation purposes and then replacing them after testing is completed. This will avoid unsightly 'Pen Marks' on the cable
- Ensure that for each group of finished labels they are aligned and attached so they are readable from the same direction.
- If the installation is a mixture of copper and fibre optic cabling install the copper cabling first
- Plan the occupation of cabling in the containment and along the route so that crossovers are eliminated and entry points into and exits from the containment are not congested
- In any cable run where the cable is to be pulled the run should contain no more than two 90° bends. If more than two 90° bends are required or the sum of all angles is greater than 180° then there must be more pull points along the cable run where the cable is able to be managed in and out of the containment
- Respect the installation bend radius of the cable. Never exceed the recommended maximum pulling load of the cables
- Determine the pulling in points which will cause damage to the cable, through sharp edges or bends tighter than the installation bend radius
- Apply any protection to the containment where damage to the cable sheath may occur. Consider using cable installation aids.
- Bundle size should be kept to a minimum
- Maximum bundle size is 24 for 4 pair twisted copper cables
- Smaller bundles make better use of limited containment space
- With mixed length cables in a cable run always pull in the longest length cables first
- Secure the stack of cable boxes or reels using a pulling frame or cable stands to hold the packaging in place
- Pulling force must be respected. Maximum pull force for a single, or bundle of cables, is 110 N (25 lbf)
- Avoid any cable kinks and maintain proper bend radius control during cabling pulling. If any kinks should occur, kinked cable should be removed and replaced
- For safety, only use cable jacks and pulling frames which are designed for and fit for purpose
- Always control the rate at which cables are pulled off the drum
- Take great care over the management of cable drum

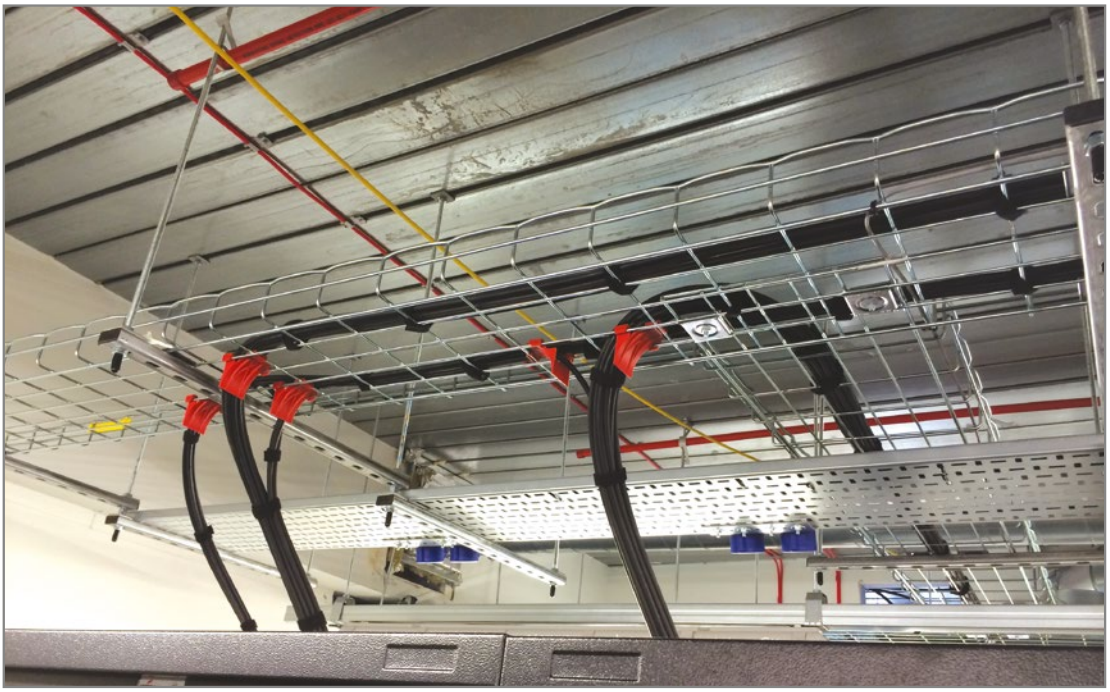


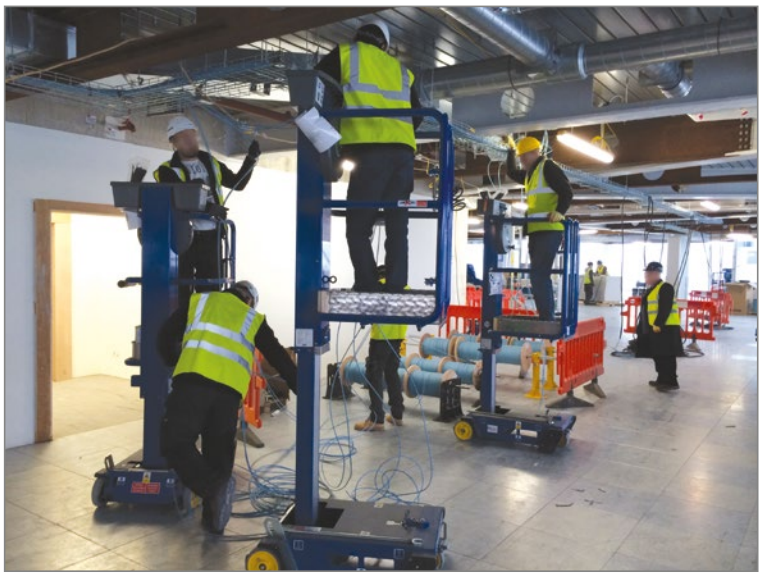
- Hook and eye cable fixings are preferred
- If nylon type zip ties are used, ensure excess is cut flush, to avoid the creation of sharp and dangerous edges
- Do not over tighten
- No deformation, marking or compression of cable jacket is allowed
- For further clarification on the use of cable ties also see tech Note TN12 in the Partner Area of www.excel-networking.com
- Acclimatise the cables to the location where they are to be installed, minimum 2 hours
- Refer to the specification sheet for the installation and operating temperature ranges for the cables being installed
- The recommended installation temperature range is 0º – 60ºC (32º – 140º F). Avoid pathways exposed to extreme thermal cycling
- Remember that for some outdoor cabling there may be a minimum installation temperature
- Do not install copper cabling or optical fibre cabling with a metallic strength member outdoors when there is a thunder or lightening storm about
- Only use approved lubricants and pulling gels for the cable type being installed
- For external installations seal the ends of all cables with a water tight product before installation

When installing cable at high level the additional requirements are as follows:

- Protect the edges of the basket or tray before starting to install the cable to ensure no damage is caused
- Ensure that the edges of the tray or basket have a bend radius that exceeds the installation Bend Radius of the cable concerned. This may be achieved by artificially increasing the dimension by the use of temporary packing material
- If bundles of cable are being routed from tray at high level to enter a cabinet from the top, some form of 'waterfall' must be used to ensure the bend radius of the cable is not compromised. This can be simply and cost effectively achieved by the use of a section of split flexible plastic conduit installed along the edge involved. The following image gives an example



- When installing cable at high level ensure that sufficient engineers are available to carry out the work, it is recommended that cables are 'passed' from one engineer to the next rather than trying to drag them over the tray. The following image will give an example of this practice.



This table lists the most common part codes for the Excel cable designs. The diameters provided are correct for all part codes to which this design is applied, for example coloured versions of Category 6 U/UTP.

| Part Number | Description | Diameter | During Installation – Bend Radius | Installed – Bend Radius |
|---|---|---|---|---|
| 100-065 | Excel Category 5e Unscreened Twisted Pair (U/UTP) Cable - PVC | 5.2 mm | 42 mm | 21 mm |
| 100-066 | Excel Category 5e Unscreened Twisted Pair (U/UTP) Cable - LSOH | 5.2 mm | 42 mm | 21 mm |
| 100-216 | Excel Category 5e Screened Twisted Pair (F/UTP) Cable - LSOH | 6.4 mm | 51 mm | 26 mm |
| 100-609 | Excel Residential Category 6 Unscreened Twisted Pair (U/UTP) Cable - LSOH | 4.6 mm | 37 mm | 19 mm |
| 100-070 | Excel Category 6 Unscreened Twisted Pair (U/UTP) Cable - PVC | 6.2 mm | 50 mm | 25 mm |
| 100-071 | Excel Category 6 Unscreened Twisted Pair (U/UTP) Cable - LSOH | 6.2 mm | 50 mm | 25 mm |
| 190-071 | Excel Category 6 Unscreened Twisted Pair (U/UTP) Cable - LSOH (B2ca) | 6.5 mm | 52 mm | 26 mm |
| 100-076 | Excel Category 6 Screened Twisted Pair (F/UTP) Cable - LSOH | 7.6 mm | 61 mm | 30 mm |
| 100-080 | Excel Category 6 (24AWG) Unscreened Twisted Pair (U/UTP) - LSOH | 5.4 mm | 44 mm | 22 mm |
| 100-189 | Excel Category 6A Unscreened Twisted Pair (U/UTP) Cable – LSOH | 8.3 mm | 67 mm | 34 mm |
| 100-191 | Excel Category 6A Screened Twisted Pair (U/FTP) ' S-Foil' Cable – LSOH | 6.7 mm | 54 mm | 27 mm |
| 100-914 | Excel Category 6A Screened Twisted Pair (S/FTP) Cable – LSOH | 7.5 mm | 60 mm | 30 mm |
| 100-196 | Excel Category 6A Screened Twisted Pair (F/FTP) ' S-Foil' Cable – LSOH | 6.9 mm | 56 mm | 28 mm |
| 100-910 | Excel Category 7A Screened Twisted Pair (S/FTP) Cable – LSOH | 7.8 mm | 63 mm | 32 mm |
| 100-912 | Excel Category 7A Screened Twisted Pair (S/FTP) Cable – LSOH (1200Mhz) | 8.5 mm | 68 mm | 34 mm |

NOTE: Accurate at time of publication, higher Euroclass levels of unscreened cables are typically slightly larger in OD so please check Specification Sheets. Please be advised that the Excel Containment Calculator has been updated to reflect this increased diameters.

# Earthing, Grounding and Bonding

Unless you are a qualified and competent electrical person leave the connection of the earthing wire onto the electrical system to the electrical trade.

The following information is for guidance purposes, Grounding and bonding of all systems should be carried out in accordance with EN50174-2, EN50310 standards.

The best type of earthing conductor used to provide a signal earth connection is a flat braided strap. Flat is best because it offers a greater surface area and braided straps because impedance is affected by length and braid offers many different routes and therefore lengths of conductor for the unwanted signals to flow along. If you use a solid core conductor to provide an earth strap you can improve this by adding a second, different length, earth conductor to reduce the possibility of an impedance issue resisting the passage of the unwanted signals.

Do not coil an earthing conductor around a screwdriver to make it look neat and tidy, you are forming a coil which can restrict the transmission of signals.

It is best practice to connect the earth stud in a cabinet onto a separate earthing bar located in the cabinet. It is recommended that the bar is provided with four or more attachment points for equipment earths to be connected onto. This is because if all of the equipment earths are run back to the earth stud then for safety reasons the electrical supply must be disconnected every time a new piece of equipment is added or removed from the cabinet.

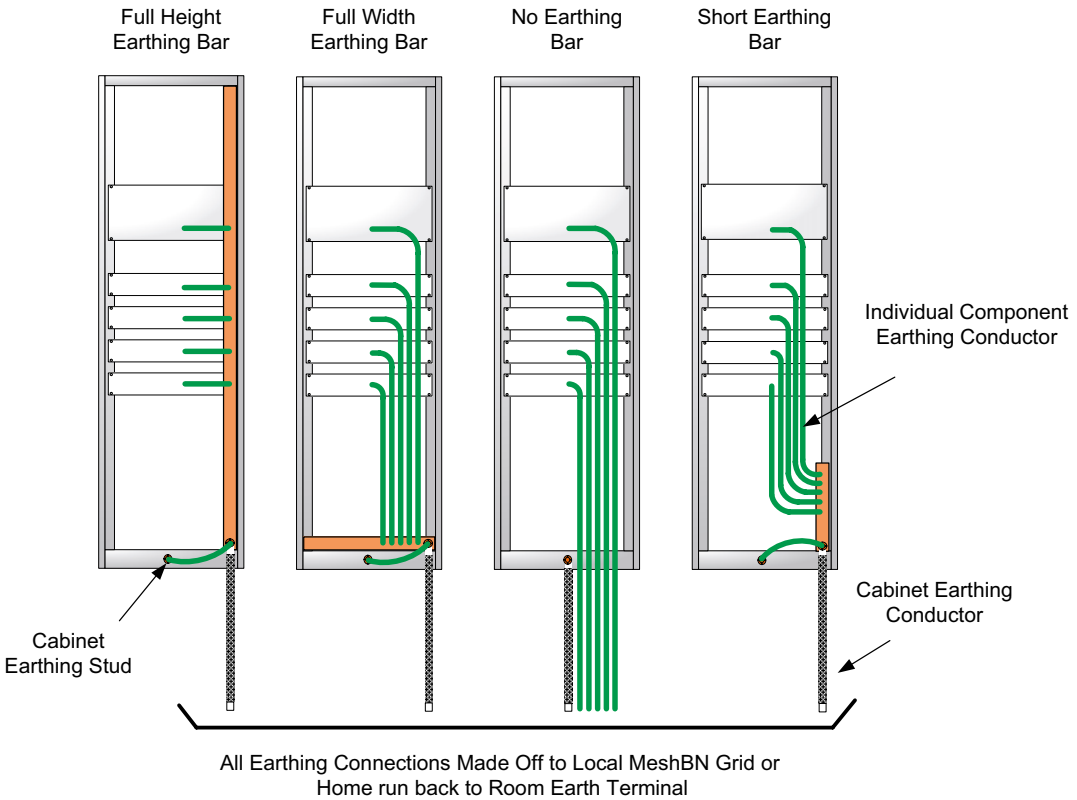
When installing a piece of equipment which requires a signal earth, always install the equipment, then attach the earth connection, then connect up the power.

ESD (Electrostatic Discharge) can kill equipment. When installing equipment into a cabinet or frame always use an ESD strap connected between you and the cabinet.

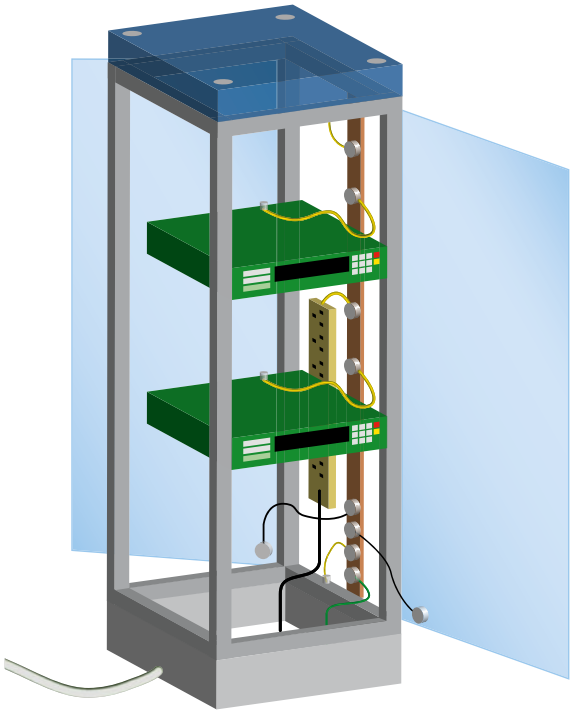
Each earthing conductor must be grounded onto a clean, purposeful earthing point. Use an approved cleaning method and bonding gel to protect the joint from oxidisation.

Do not daisy chain earthing conductors; the only exception to this is where there is a run of metallic cable containment when each length must be grounded onto the next.

## Example of Cabinet Earthing



## Example of Rack Earthing



The best practices for communications rooms and data centres recommend provision of an equipotential earthing grid or MESH-BN (a bonding network in which all associated equipment frames, racks and cabinets and usually the DC power return conductor, are bonded together as well as at multiple points to the Common Bonding Network).

This grid is used to earth all of the metallic components (frames, racks, floor tiles and pedestals, cable containment, etc) providing:

- a reliable signal reference
- adequate immunity from electromagnetic interference carried by the earthing network

Each rack and frame must be provided with an earthing conductor made back to either the MESH-BN or home run back to the main communications grounding bar within the room. For some installations this may be the electrical earthing bar in the main power distribution board.

Within the UK the specification for the rack earth connection is covered by:

BS6701:2016 + A1:2017 Telecommunications equipment and telecommunications cabling specification for installation, operation and maintenance.

5-2.2.4 Earthing of racks, frames and cabinets.

Not less than:

- $4mm^2$ for a rack ≤ 21U
- $16mm^2$ for a rack > 21U

(please refer to the standard for further details)

# Racks and Frames

- Install the racks and frames in the pre assigned positions.
- Check alignment of any containment with the cable entrances (for power and data) to the rack.
- Apply temporary labels to identify the location.
- Secure the racks and frames to the solid floor and/or wall to provide stability when loaded with equipment and cabling.
- Install any baying or joining components.
- Attach the earthing kit to all rack and frame components.
- Connect the main earthing conductor.
- Does the site require blanking panels for airflow management in the racks and/or frames?

The layout for the inside of each rack should be determined in the overall site design. As with a lot of new designs there are great pressures on the space available within the racks and frames. As a general rule for laying out a rack, begin at the top with the patch panels starting with optical fibre panels then copper panels. The top most position in a block of patch panels should be reserved for a horizontal wire manager, then there should be no more than two patch panels of 1U height followed by another horizontal wire manager. On high density frames the front fingers of the vertical wire manager provide the support for patch cords so there is not the same level of requirements for horizontal wire managers. Horizontal raceways will be required to facilitate shortest routing between patch panel outlets.

- When installing panels and wire managers use all of the securing and fixing holes provided.

NB. It is essential that all cable bundles entering a rack, either from the top or the bottom, are securely attached to cable tray within the rack and under no circumstances should they be solely supported by the rear management of the Patch Panel.

# Patch Panels

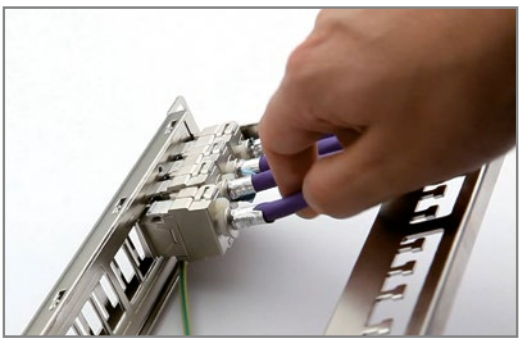
Termination procedures at the patch panel:

- It is acceptable for the cables to be dressed as either, 24 cables from one side or split as 12 from each.
- Maintain acceptable bend radius levels
- Do not kink cables
- Do not overtighten the cable ties to deform the cable in any way.
- Where a rear management bar is provided each cable should be individually secured by way of a cable tie, 'bunching' or grouping of cables is deemed to be a poor installation practice.
- For Category 6 and above, best practice dictates all cables shall be individually terminated and secured to the management bars provided. This has the two benefits of improved performance and ease of re-termination if a wire map error is discovered during testing without the need to disturb any adjacent outlets on the same panel.

To enhance wire management in the back of the panel, it is recommended that the cable tray is is mounted to the rack. Along the tray use hook and eye cable ties for additional cable management.

Termination procedures for the punch down patch panel:

- Follow installation instruction sheet
- Outer cable jacket should be trimmed to be as close as possible to point of termination
- Last twist should be no further than 13 mm (0.5 inches) from the point of termination.



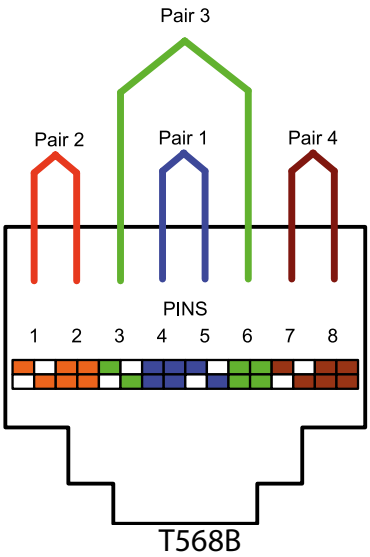
# Wall Boxes and Desk Outlets

For a duplex, twin outlet presentation, choose a back box that complies with the minimum bend radius of the cable.

If metal GOP boxes or metal face plates are used, ensure that there is a grounding facility / earthing lug and a suitably sized earth wire connection, with sufficient cable to earth the box and lid.

# Colour code

The colour code or punch down followed by Excel for all of their cabling system components is the T568B format.



# Suggested Minimum Back Box Depth

## Bevelled Euro Faceplate

| | | | Face Plate | 100-712 Single & 100-716 Double Gang Bevelled | | |
|---|---|---|---|---|---|---|
| | | | Shutter | 100-014 | 100-020 | 100-175 | Nil |
| | Jack | Direction of Incoming Cable | Euromod 25 x 50mm Flat Keystone Shutter - White | Category $6_A$ Angled Shutter for Keystone Jack 50x25mm, White | Euromod 25 x 50mm Angled Keystone Shutter - White | |
| CAT6A | 100-181 Cat $6_A$ Low Profile | Top | 52 mm | 25 mm | 30 mm | |
| | | Bottom | 52 mm | | | |
| | | Side | 52 mm | | | |
| | 100-182 Cat $6_A$ Unscreened | Top | 62 mm | 30 mm | 35 mm | |
| | | Bottom | 62 mm | | | |
| | | Side | 62 mm | | | |
| CAT6 | 100-300 Cat 6 Unscreened Module | Top | | | | 22 mm |
| | | Bottom | | | | 22 mm |
| | | Side | | | | 22 mm |
| | 100-366 Cat 6 Unscreened Low Profile | Top | | | | 5 mm |
| | | Bottom | | | | 15 mm |
| | | Side | | | | 5 mm |
| | 100-011 Cat 6 Keystone IDC | Top | 30 mm | 19 mm | 19 mm | |
| | | Bottom | 30 mm | | | |
| | | Side | 30 mm | | | |
| | 100-211 Cat 6 Toolless Jack | Top | 33 mm | 25 mm | 29 mm | |
| | | Bottom | 33 mm | | | |
| | | Side | 33 mm | | | |
| | 100-210 Cat 6 Screened Toolless Jack | Top | 63 mm | 30 mm | 35 mm | |
| | | Bottom | 63 mm | | | |
| | | Side | 63 mm | | | |
| CAT5e | 100-760 Cat 5e Unscreened Low Profile | Top | | | | 5 mm |
| | | Bottom | | | | 14 mm |
| | | Side | | | | 5 mm |
| | 100-010 Cat 5e Keystone IDC | Top | 29 mm | 19 mm | 23 mm | |
| | | Bottom | 29 mm | | | |
| | | Side | 29 mm | | | |
| | 100-203 Cat 5e Toolless Jack | Top | 32 mm | 25 mm | 29 mm | |
| | | Bottom | 32 mm | | | |
| | | Side | 32 mm | | | |
| | 100-906 Cat 5e Screened Toolless Jack | Top | 63 mm | 30 mm | 35 mm | |
| | | Bottom | 63 mm | | | |
| | | Side | 63 mm | | | |

# Suggested Minimum Back Box Depth

## Flat Euro Faceplate

| | | | Face Plate | 100-714 Single & 100-718 Double Gang Flat | | | |
|---|---|---|---|---|---|---|---|
| | | | Shutter | 100-014 | 100-020 | 100-175 | Nil |
| | Jack | | Direction of Incoming Cable | Euromod 25 x 50mm Flat Keystone Shutter - White | Category $6_A$ Angled Shutter for Keystone Jack 50x25mm, White | Euromod 25 x 50mm Angled Keystone Shutter - White | |
| CAT6A | 100-181 Cat $6_A$ Low Profile | | Top | 58 mm | 31 mm | 36 mm | |
| | | | Bottom | 58 mm | | | |
| | | | Side | 58 mm | | | |
| | 100-182 Cat $6_A$ Unscreened | | Top | 68 mm | 36 mm | 41 mm | |
| | | | Bottom | 68 mm | | | |
| | | | Side | 68 mm | | | |
| CAT6 | 100-300 Cat 6 Unscreened Module | | Top | | | | 28 mm |
| | | | Bottom | | | | 28 mm |
| | | | Side | | | | 28 mm |
| | 100-366 Cat 6 Unscreened Low Profile | | Top | | | | 11 mm |
| | | | Bottom | | | | 21 mm |
| | | | Side | | | | 11 mm |
| | 100-011 Cat 6 Keystone IDC | | Top | 36 mm | 25 mm | 25 mm | |
| | | | Bottom | 36 mm | | | |
| | | | Side | 36 mm | | | |
| | 100-211 Cat 6 Toolless Jack | | Top | 39 mm | 31 mm | 35 mm | |
| | | | Bottom | 39 mm | | | |
| | | | Side | 39 mm | | | |
| | 100-210 Cat 6 Screened Toolless Jack | | Top | 69 mm | 36 mm | 41 mm | |
| | | | Bottom | 69 mm | | | |
| | | | Side | 69 mm | | | |
| CAT5e | 100-760 Cat 5e Unscreened Low Profile | | Top | | | | 11 mm |
| | | | Bottom | | | | 20 mm |
| | | | Side | | | | 11 mm |
| | 100-010 Cat 5e Keystone IDC | | Top | 35 mm | 35 mm | 29 mm | |
| | | | Bottom | 35 mm | | | |
| | | | Side | 35 mm | | | |
| | 100-203 Cat 5e Toolless Jack | | Top | 38 mm | 31 mm | 35 mm | |
| | | | Bottom | 38 mm | | | |
| | | | Side | 38 mm | | | |
| | 100-906 Cat 5e Screened Toolless Jack | | Top | 69 mm | 36 mm | 41 mm | |
| | | | Bottom | 69 mm | | | |
| | | | Side | 69 mm | | | |

# Suggested Minimum Back Box Depth

## 6c Faceplates

| | | Face Plate | 100-670 Single & 100-671 Double Gang 6c Faceplate | | |
|---|---|---|---|---|---|
| | | Shutter | 100-018 | 100-022 | Nil |
| | Jack | Direction of Incoming Cable | 6c Flat Keystone Shutter | 6c Angled Keystone Shutter | |
| CAT6A | 100-181 Cat 6A Low Profile | Top | 50 mm | 30 mm | |
| | | Bottom | 50 mm | | |
| | | Side | 50 mm | | |
| | 100-182 Cat 6A Unscreened | Top | 60 mm | 30 mm | |
| | | Bottom | 60 mm | | |
| | | Side | 60 mm | | |
| CAT6 | 100-301 Cat 6 Unscreened 6c | Top | | | 21 mm |
| | | Bottom | | | 21 mm |
| | | Side | | | 21 mm |
| | 100-011 Cat 6 Keystone IDC | Top | 27 mm | 22 mm | |
| | | Bottom | 27 mm | | |
| | | Side | 27 mm | | |
| | 100-211 Cat 6 Toolless Jack | Top | 60 mm | 30 mm | |
| | | Bottom | 60 mm | | |
| | | Side | 60 mm | | |
| | 100-210 Cat 6 Screened Toolless Jack | Top | 60 mm | 30 mm | |
| | | Bottom | 60 mm | | |
| | | Side | 60 mm | | |
| CAT5e | 100-758 Cat 5e Unscreened Low Profile | Top | | | 20 mm |
| | | Bottom | | | 20 mm |
| | | Side | | | 20 mm |
| | 100-010 Cat 5e Keystone IDC | Top | 26 mm | 22 mm | |
| | | Bottom | 26 mm | | |
| | | Side | 26 mm | | |
| | 100-203 Cat 5e Toolless Jack | Top | 29 mm | 22 mm | |
| | | Bottom | 29 mm | | |
| | | Side | 29 mm | | |
| | 100-906 Cat 5e Screened Toolless Jack | Top | 60 mm | 30 mm | |
| | | Bottom | 60 mm | | |
| | | Side | 60 mm | | |

# Suggested Minimum Back Box Depth

Office

| | | Face Plate | Single & Double Gang Office | Floor Box Plate |
|---|---|---|---|---|
| | | **Shutter** | 100-280 | Nil |
| | **Jack** | Direction of Incoming Cable | Office Angled Keystone Shutter | |
| CAT6A | 100-181 Cat 6A Low Profile | Top | 22 mm | |
| | | Bottom | | |
| | | Side | | |
| | 100-182 Cat 6A Unscreened | Top | 35 mm | |
| | | Bottom | | |
| | | Side | | |
| CAT6 | 100-276 Office Cat 6 Low Profile | Top | | 10 mm |
| | | Bottom | | 20 mm |
| | | Side | | 10 mm |
| | 100-011 Cat 6 Keystone IDC | Top | 23 mm | |
| | | Bottom | | |
| | | Side | | |
| | 100-211 Cat 6 Toolless Jack | Top | 32 mm | |
| | | Bottom | | |
| | | Side | | |
| | 100-210 Cat 6 Screened Toolless Jack | Top | 45 mm | |
| | | Bottom | | |
| | | Side | | |
| | 100-297 Cat 6 Low Profile 6c | Top | | 18 mm |
| | | Bottom | | 20 mm |
| | | Side | | |
| CAT5e | 100-275 Office Cat 5e Low Profile | Top | | 10 mm |
| | | Bottom | | 19 mm |
| | | Side | | 10 mm |
| | 100-010 Cat 5e Keystone IDC | Top | 23 mm | |
| | | Bottom | | |
| | | Side | | |
| | 100-203 Cat 5e Toolless Jack | Top | 32 mm | |
| | | Bottom | | |
| | | Side | | |
| | 100-906 Cat 5e Screened Toolless Jack | Top | 45 mm | |
| | | Bottom | | |
| | | Side | | |
| | 100-757 Cat 5e Low Profile 6c | Top | | 18 mm |
| | | Bottom | | 20 mm |
| | | Side | | |

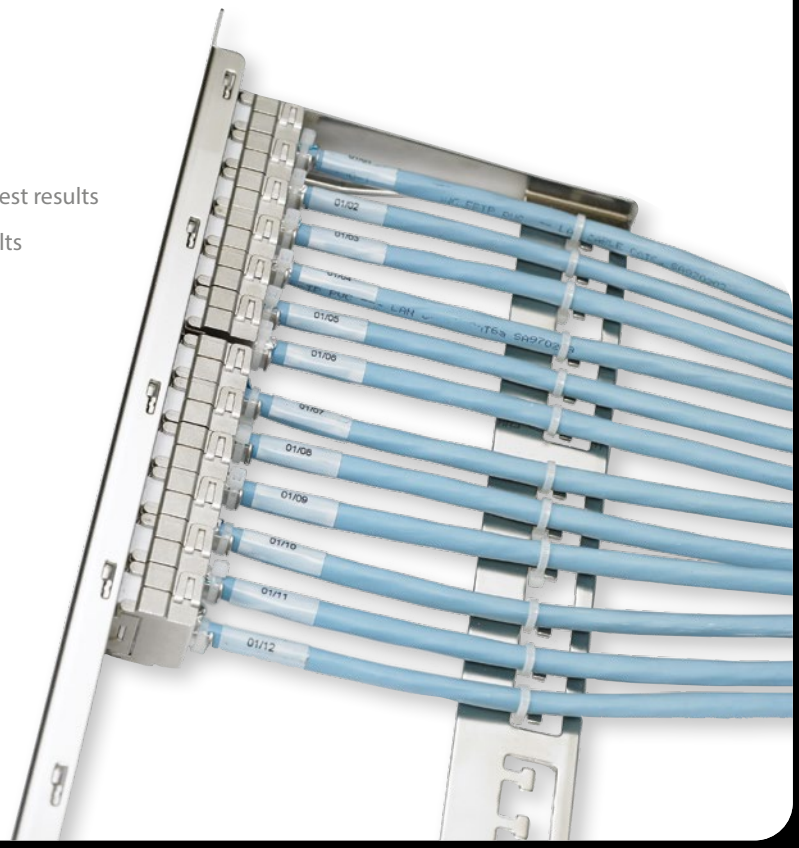
# Operation & Maintenance

The Operation and Maintenance manual or documentation handed over to the client at the end of the job is a record of what has been provided with information about the products, how they have been implemented and the testing records.

Please note there may also be local codes and regulations, that outline how this documentation should be compiled.

An O&M package should include:

- As built drawings showing:
  - Date of installation completion
  - Site identity / location identity
  - Location of outlets
  - Identity of outlets
  - Location of cabinet and frames
  - Identity of cabinet and frames
    - *If required with occupancy and capacity of cabinet and frames*
  - Pathways used
    - *If required identity of pathways*
    - *If required with occupancy and capacity of pathways*
  - Fire stopping
    - *If required identity of fire stop with occupancy and capacity*
  - Grounding / earthing points
    - *If required identity of grounding / earthing and connections*
- Details of the product set used throughout the installation including:
  - Product part numbers
  - Product specification sheets. (don't forget to use branded specification sheets - refer to the website section 18 to see how to add your company logo and details)
  - Label format and typeface
  - Bill Of Materials
- Summary test result sheets for all outlets and tested components
  - CD (or other electronic medium) of the detailed test results
  - Copy of the Fluke Linkware used to view the results
- Details of the test equipment used to certify the performance of the cabling system
- Calibration certificates for the test equipment used
- Details of the test methods used
- Warranty certificates from Excel
- Details of any routine or periodic maintenance requirements including cleaning methods and materials
- Contact details for the installer



# Testing

Excel recommends Fluke Networks, this section is written around the use of this range of test equipment.

## Twisted Pair Copper

This section describes and sets out the requirements for Class D (Cat 5e) , Class E (Cat 6) and Class EA (Cat 6A) balanced twisted pair copper Permanent Link testing and Channel testing for the Excel warranty.

The preferred test equipment is a Fluke DSX 5000. There is a list of acceptable alternatives in the Warranty Section of the Partner Area at www.excel-networking.com

### Permanent Link Testing

The test set must be fitted with a set of:

- Fluke Permanent Link Adapter PLA004

### Channel Testing

The test set must be fitted with a set of Fluke Channel test heads.

### Modular Plug Terminated Link (MPTL)

- For use with harness and switch links
- Used for testing directly connected devices such as WiFi access points and IP CCTV cameras
- Requires the use of one Permanent Link Adapter PLA004 and one Patch Lead Test Head

UPDATED for V5

## IMPORTANT:

- Permanent Link Adapters must be 'serviced' every 5,000 tests.
- Channel Test heads last for a maximum of 2,000 tests, and cannot be serviced, they should be discarded and new ones purchased. N.B. This number is based on the amount of matings, i.e. how often a Patch Lead is plugged into them. When testing a channel you MUST leave that Patch Lead behind or that channel test is no longer valid.
- The test set must be within 12 months of calibration.
- Tests must be run with Graphs Stored enabled and HDTDR / HDTDX recorded for all *PASS/FAIL.
- All Channel Test Heads, Personality Modules or Personality Module tips must be frequently inspected for damage or undue wear.
- Power frequency must be set to 50Hz.
- Limits database and software must be as per the product set under test and Excel warranty requirement.
- The test limits for Excel are CENELEC EN50173 series including all latest amendments, modified by the copper cable type under test (Class D, Class E, etc). If there is any doubt for installed cabling regarding which component performance specification to be used, confirmation should be sought from the client or Project Manager and referred back to Excel for approval under their warranty scheme.
- Installers should budget and schedule for replacement of Channel Test Heads, PLA4 tips and Personality Modules. The replacement rate may be lower than recommended or required depending on wear and condition of the test equipment on site.

## Tester Log Sheet

A tester and test set component usage log sheet must be kept with each test set and maintained by the operator of the test set. The tester log must record the components within the test set including:

- test set ID (serial numbers from all major components)
- test cord ID
- test head serial numbers (PLA and Channel Head)
- calibration status (date of calibration for each component)
- component usage (number of tests executed)
- operator ID (name and company)

Replacement of ALL Copper Reference Test Cords is mandatory when they have completed 100 tests or earlier if damage is present on the test cord connectors.

## At The Start of Each Day

- Check that the batteries are fully charged
- Check all results from the previous day have been off loaded onto a laptop
- Perform a visual check on the condition of the tester components for wear or damage
- Fill out the tester log sheet and confirm all the tester components and leads are within their usage limits
- Plug the designated main end Channel Head or PLA into the main end of the tester
- Plug the designated remote end Channel Head or PLA into the remote end tester
- Enter operator name site and starting cable ID to be tested

NOTE: Every 6 Months (immediately after calibration and then +6 months) run set up on the PLA heads

## For Each Project

- Enter the NVP for the cable obtained from the product specification sheet
- All Excel Cables are stored under 'Manufacturers' within the DSX setup tab
- Enter the performance level specification for the Channel or Permanent Link to be tested CENELEC EN50173 Class $E_A$, Class E, etc.

## Recommendations

- Perform a basic wire map test before using the Fluke tester to fault find
- Have a laptop computer on site with the latest version of Fluke Linkware installed
- Identify Main and Remote on the Channel adapters and PLA with a permanent ink pen or label ID system

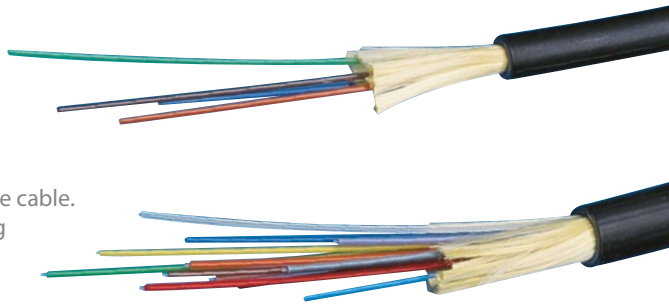
Excel requires a copy of the test results in Fluke software (flw) or the alternative testers native format. Excel will not accept .pdf files under any circumstances.

Each report will be stored by Excel.

The Installer will be provided with a copy of the Channel Warranty documentation Excel will endeavour to process Warranty Application within 5 working days if the process contained in Section 16 is followed.

# Fibre Specific

## Overview



Optical fibres require special care during installation to ensure reliable operation. Installation guidelines regarding minimum bend radius, tensile loads, twisting, squeezing, or pinching of cable must be followed. Cable connectors should be protected from contamination and scratching at all times. Violation of any of these parameters causes increased attenuation or permanent damage to the cable. The following are a few general comments to consider when installing fibre optic cables.

## Duct and Direct Burial Fibre

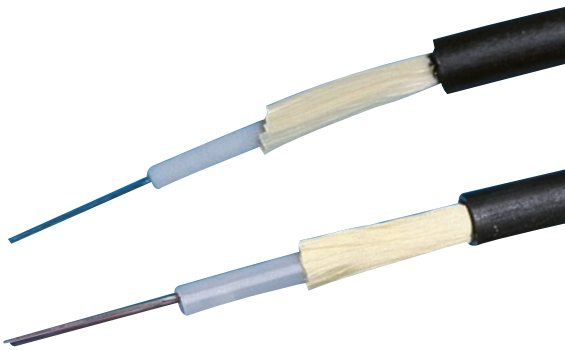
NEW for V5

There is much confusion by terms Duct Grade and Direct Burial, it is important to choose the correct one for your environment. There are several key factors to consider when making your decision.

### Installation Environment

The installation environment will determine whether you require duct grade or direct burial

The following questions will help understand what cable to install and why:



- What is the local climate?
- Is the area typically dry with low humidity and relatively little moisture?
- Are the cable ducts dry?
- Is the environment wet?
- Will you be laying the cabling near known water sources like ponds, lakes, or rivers?
- Will flooding impact ducts and inspection pits?

Harsher local environments will require different sheath materials. For example, PVC sheathing won't be enough in areas where the temperature regularly goes below 20 degrees Celsius. By carefully evaluating the installation environment, it is possible to select cable specification tolerances to meet the requirements.

### Direct Burial

As the name suggests, direct burial cable is designed to be buried in the ground underground sometimes in an outer duct or straight into a trench cut in the earth. Duct grade cable designed to be installed into cable ducts typically above ground. These offer obvious advantages over conventional overhead cable as they do not require an additional catenary wire to support them.

Because it is installed underground, direct burial cable is designed to withstand the elements. It must be able to deal with temperature shifts, moisture, and pests over the long term. The added moisture and temperature resistance can make Direct Burial cable more expensive than standard cabling.

It helps to have a clear idea about which direct burial or duct cable work best for your application. By balancing the cables specification and local environmental characteristics, you can select DI cable at the protection level you need.

### Dry Duct

The term Dry duct generally refers to duct routing within the fabric of a building between floors or short distances between buildings not greater than 100m. The emphasis is on the internal environment within the duct remaining at the same ambient temperature as the building/s it services.

Where an Excel cable is described as "Duct Grade" but is constructed with a LS0H sheath, this is referring to installation within a Dry duct application.

### Civil Ducts

Civil ducts are installed for two primary reason the first is to protect the services being installed whether it be Data, Electrical, Water or Gas. The second is to protect the environment from the services installed provisionally Water or Gas. The general requirement for the installation of a Civil duct is usually but not always simply due to distance. Where it is not practical or safe to install services above ground, a network of ducts to allow the distribution of services.

Where an Excel cable is described as "Duct Grade" and is PE sheathed, it is referring to installation within a civil duct application.

Note: even with PE sheathed they should not be filled with water for extended periods, this would require a more specialist 'submersible' cable.

### Armoured Cables

If a cable needs to be directly buried into the ground, an armoured construction is recommended. Armoured cables such as SWA (steel wire armour) and CST (corrugated steel tape) are constructed with both metallic elements and water proofing technology to enable to withstand harsh environment and are also suitable for both Dry and Civil ducts.

Note: if these are being brought into the building for the final termination they will need to grounded and bonded for safety rather than performance purposes, guidance for how this is to be carried out should be sought from the Electrical Engineer on the project.

### Cable Sheath

There are two primary options when choosing cable sheath for Duct or Direct Burial cables: PVC or PE cable sheathing. PVC cable sheaths can withstand temperatures between -20 C to +70 C.

This means if you're laying down cabling in very cold environments where the temperature drops below -20 C, PVC cabling is not a viable option.

Polyethylene (PE) sheaths are more expensive but, they remain stable over a much wider range of temperatures. PE sheaths can be used in areas where the temperature is as low as -40 C.

Excel Enbeam Duct Grade and Direct Burial cables are PE sheathed.

### Water Resistance

Not all direct installation or duct cables offer water resistance. The level of water resistance needed will depend on the installation environment. Different levels of water resistance have different strengths and weaknesses.

Direct burial cables feature different kinds of waterproofing:

- Tape-shielded cables use multiple layers of dry, waterproof tape to offer a substantial level of water resistance
- Gel-filled cabling is the most common method of water resistance cabling. These cables are filled with a petroleum-based waterproof insulating gel which prevents water from travelling within the cable. Gel-filled cables offer significantly better water resistance than tape-shielded cable. However, the gel substance makes this type of cable more difficult to install and maintain.
- Dry Loose Tube, some installations will not allow petroleum-based gel and therefore a construction has been developed that uses a combination of the Tape shielding and dry powder that swells in the presence of moisture to prevent the water travelling along the cable.

Excel Enbeam Duct Grade and Direct Burial cables are typically gel-filled but a dry loose-tube version is available on request.

## Do not exceed maximum cable lengths

Make sure you check the installation instructions of the module for the appropriate cable lengths to ensure proper operation. You may experience additional attenuation loss when using bulkhead connectors to join cables even when the total length is less than the maximum allowed. Care should be used in maintaining total attenuation budget when joining cables with bulkhead connectors.

## Do not compromise minimum bend radius for a given cable type

Exceeding the bend radius of the cable can cause unseen damage to the fibres of the cables that may not manifest itself for a period of time. This can lead to an expensive re-pulling of cables at a later date.

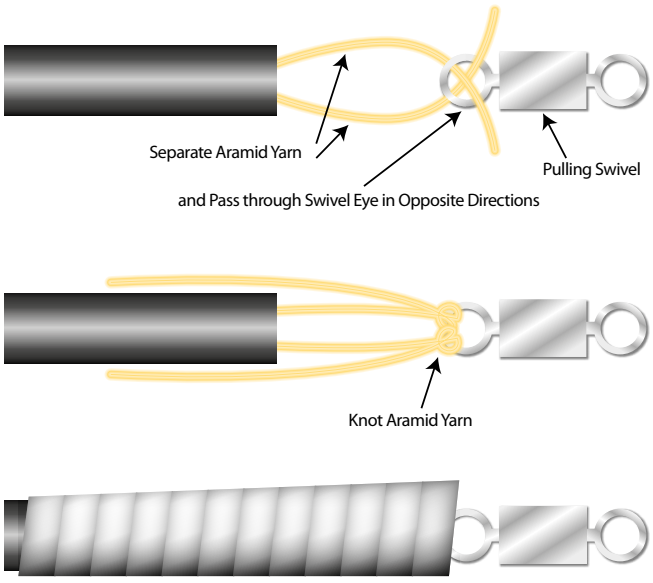
## Avoid twisting cable

Use proper pulling techniques when installing the cables. Putting twists in the cable greatly increases the chances of breaking the fibres.

# Fibre Optic Cable Pulling Techniques

Installation methods for both wire cables and optical fibre cables are similar. Just remember these rules:

- Never pull on the connector. The connector/cable interface is not designed for pulling
- Use a pulling grip designed for pre-connected fibre optic cables. Grips with a fixed pull ring should use a swivel to attach the pull rope
- Monitor tension. Do not exceed the maximum tensile load.
  - On runs from 40m to 100m, use proper lubricants and make sure they are compatible with the cable jacket
  - On runs over 100m, use proper lubricants and pull from the middle out to both ends
  - If possible, use an automated puller with tension control or at least a breakaway-pulling eye
- Always use a straight pull. Use cable guides to maintain the recommended bend radius. Do not exceed the cable bend radius. Exceeding the bend radius harms the fibres. It may not be immediate, it may even take a few years but eventually by exceeding the recommended bend radius of the cable you reduce the useful life of the cable
- Use a swivel-pulling eye, to prevent additional twisting of the cable during installation.




# Routing Fibre Optic Cables

Take care to properly route cables through cabinets and right angle bends within cable tray.

- **Install cables in containment without loops.** Avoid placing fibre optic cables in containment and conduits with copper cables to avoid excessive loading or twisting
- **Protect cables from excessive or frequent bending.** Cables do not have a flex rating. Special care must be taken to protect the cable and to avoid exceeding the bend radius of the cable

# Installation Checklist

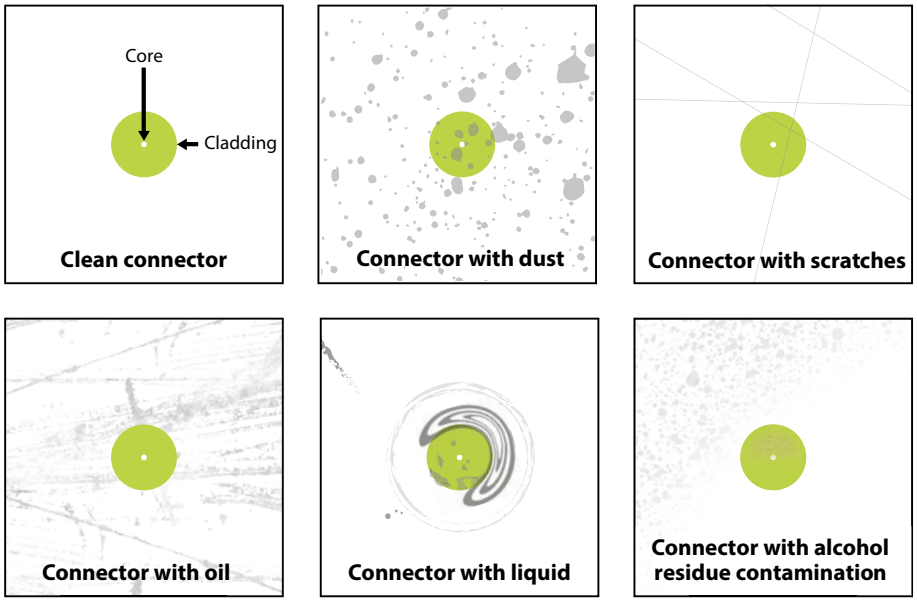
Use the following installation checklist to ensure proper handling.

| Installation Procedure | Complete | Comments |
|---|---|---|
| Maximum cable length not exceeded | | |
| Bending radius not exceeded | | |
| Maximum tensile load not exceeded | | |
| Correct pulling techniques used | | |
| Cable not squeezed or jacket creased | | |
| Cable installed without loops in containment | | |
| Cable protected from sharp edges | | |
| Fibre cable installed in separate containment or route to copper cable | | |
| Communications Spaces thoroughly cleaned prior to termination of fibre cables, (direct or splicing). | | |
| Fibre connector end face cleanliness maintained | | |
| Fibre connector dust caps in place | | |
| Correct labelling of both fibre cables and panels | | |

UPDATED for V5

# Cleaning Techniques for Fibre Optic Cables

Any contamination in the fibre connection can cause failure of the component or failure of the whole system. Even microscopic dust particles can cause a variety of problems for optical connections. In a survey carried out by Fluke Networks they claim that 85% of the failing links can be attributed to 'end-face contamination'.



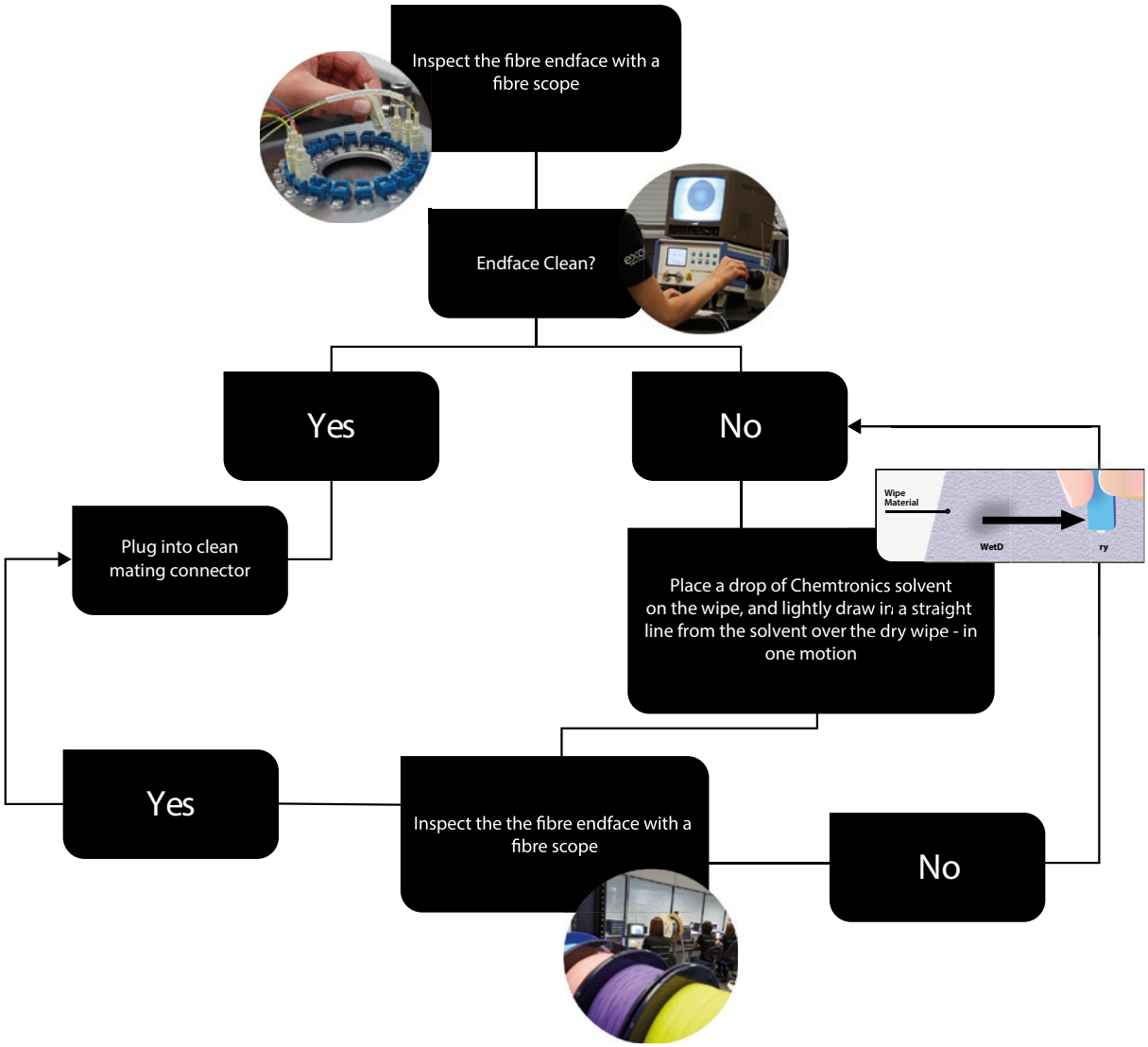

Proper cleaning of the fibre optic cable ends and transceivers is essential to minimize system attenuation.

Dirty fibre optic connectors cross contaminate their mating transceivers. Conversely a dirty transceiver contaminates its mating fibre optic connector. There are a variety of ways to clean fibre optic components. Pre-packaged wipes, swabs and, canned air are suitable. Whatever the choice, it is important to follow the correct procedure/instructions. Failure to do so could lead to even more contamination being introduced.

When installing fibre optics, the tolerance to dirt and contamination is zero, so it is important to choose the right cleaning process:

| | PROs | CONs |
|---|---|---|
| Dry Cleaning | • Can be effective for removing oily and liquid contamination<br>• Useful for removing dry debris such as dust and dirt particles | • Tends to move - not remove - debris and contamination<br>• Unreliable method<br>• Can generate a static field which attracts additional contamination<br>• Additional debris can damage a connection, which can magnify loss |
| Wet Cleaning | • An advance of the "dry" technique<br>• Static generation is reduced | • There is a danger of flooding the connector, drawing contamination from around the ferrule and further contaminating the connector |
| Combination Cleaning | • Minimal amount of a precision solvent with the ability to remove the widest range of debris and contamination<br>• A no-linting, highly absorbent wiping material<br>• An integrated drying step within the cleaning procedure<br>• Proven cleaning effectiveness | |

The following is a flow chart outlining the suggested Excel process for cleaning fibre connectors.




Watch the Combination Cleaning Process!

UPDATED for V5

## Conclusion

Cleaning fibre is an essential process of any installation and there are a number of key elements to ensure success.

They are:

- Never touch the end-face of the fibre connectors – natural body oil can be a major cause of contamination
- Always keep a protective cap on unplugged fibre connectors – protection from both damage and contamination
- Do not clean bulkhead connectors without a way of inspecting them – how else will you know whether the cleaning is successful?
- Always store unused protective caps in a sealed container - they can also be a major source of contamination if not stored in a clean environment.
- Never re-use any tissue, swab or cleaning cassette reel
- Never touch any portion of tissue or swab where alcohol was applied – you could be introducing both dirt and body oil
- Never use a wet cleaning method without a way of dry cleaning immediately afterwards - the wet process can leave a harmful residue that is hard to remove when it dries

Finally, be warned:

Ensure all the fibre connectors you intend to clean are disconnected. And **NEVER** look into a fibre with either a fibre microscope or the naked eye when the lasers are on.

For more information about the importance of keeping fibre clean, take a look at our infographic


To see all the products and tools we offer to help you keep your fibre clean, read our Fibre Cleaning Guide.

# Termination Options

There are a number of methods for the termination of fibre connectors each one has its own merits and benefits, in ease of termination, cost and convenience. One factor that remains consistent across all of them is the importance of cleanliness.

Multimode connectors are usually installed in the field on the cables after pulling this may include direct termination or splicing of pre-termination of factory-made "pig-tails". While single-mode connectors are usually installed by splicing a factory-made "pigtail" onto the fibre this is due to the tolerances on single-mode terminations being much tighter and the polishing processes more critical and you may not be able to get losses lower than 1 dB with field termination.

Pre-terminated cables can be pulled with connectors already on them if, you clearly understand the potential issues: Firstly, the length must be precise, too long and you may have to store the extra cable length. Secondly, the connectors must be protected. Excel offers protective sleeves to cover the connectors, but you must still be careful in pulling cables. In fact you may consider terminating one end and pulling the un-terminated end to not risk the connectors.

There is a growing movement to install pre-terminated systems especially with MPO/MTP 12 multi-fibre connectors.

## Direct termination – Epoxy, Hot Melt, Anaerobic Adhesive, Crimp & Polish

A note on adhesives: Most connectors use epoxies or other adhesives to hold the fibre in the connector. Use only the specified epoxy, as the fibre to ferrule bond is critical for low loss and long term reliability.

### Epoxy/Polish

Most connectors are the simple "epoxy/polish" type where the fibre is glued into the connector with epoxy and the end polished with special polishing film. These provide the most reliable connection, lowest losses (less than 0.5 dB) and lowest costs, especially if you are doing a lot of connectors. The epoxy can be allowed to set overnight or cured in an inexpensive oven. A "heat gun" should never be used to try to cure the epoxy faster as the uneven heat may not cure all the epoxy.

### "Hot Melt"

This is a 3M trade name for a connector that already has the epoxy (heat set glue) inside the connector. You strip the cable, insert it in the connector, crimp it, and put it in a special oven. In a few minutes, the glue is melted, so you remove the connector, let it cool and it is ready to polish. Fast and easy, low loss, but not as cheap as the epoxy type, it is seen as suitable for relatively small quantities of connectors.

### Anaerobic Adhesives

These connectors use a quick setting adhesive to replace the epoxy. They work well if your technique is good, but often they do not have the wide temperature range of epoxies, so only use them indoors.

### Crimp/Polish

Rather than glue the fibre in the connector, these connectors use a crimp on the fibre to hold it in. Expect to trade higher losses for the faster termination speed. These connectors are more costly than epoxy polish types. A good choice only if you install small quantities and the customer will accept them.

### Hints for field terminating connectors

- Have the right tools for the job and ensure they are in good condition.
- Is your Test Equipment and Leads in perfect condition?
- Ensure you have the means to inspect the end-faces.
- Dust and dirt are your enemies work in the cleanest possible location.
- Use lint-free wipes to clean every connector before connecting or testing it.
- Don't work under heating vents, they distribute dirty air.
- Don't over-polish, too much polishing is just as bad as too little. Polish too much and you create a concave fibre surface, increasing the loss.
- Change polishing film regularly. Polishing builds up residue and dirt on the film that can cause problems.
- Put covers on connectors and patch panels when not in use.
- Inspect and test, then document.

## Splicing – Mechanical or Fusion

There are two types of splices, fusion and mechanical, and the choice is based on quantity, expected lifecycle and location.

### Fusion Splices

These are made by "welding" the two fibres together usually by an electric arc. Obviously, it is not advisable in an explosive atmosphere. A good fusion splicer is usually fully automatic which gives maximum assistance and ensures good splices time after time.

This is the preferred option for field termination of Excel Fibre Systems due to the accuracy and consistency of Fusion Splicing of Excel warranted pre-terminated pigtails.

For full details on the correct procedures for Fusion Splicing please visit the following link.

**http://www.fujikura.co.uk/products/videos/**

### Mechanical Splices

These are alignment devices that hold the ends of two fibres together with some index matching gel or glue between them there are a number of types of mechanical splices however they should only be used for temporary repairs and not long term installations covered by the Excel 25 year warranty.

## Pre-terminated

The Excel pre-terminated fibre optic portfolio is available in OM1, OM2, OM3, OM4 & OM5 multimode and OS2 single-mode categories of system. The choice of cable type allows for the assembly to match the environment that it will be installed.

Standard fibre termination is a costly exercise requiring highly skilled engineers and specialist equipment to complete an installation. With the Excel fibre pre-terminated solution it provides a fully tested fibre loom that can be installed by non-specialist personnel, vastly reducing the installation time onsite.

**IMPORTANT NOTE:**

Using pre-terminated assemblies is no excuse for a lack of cleanliness within the Communication Room the fibre connectors are still susceptible to air borne contamination, the rules regarding inspection and cleaning prior to plugging a connector into a device or patch panel outlined earlier remains the same.

# Field Testing Overview

In order to test the performance of a Fibre system several key measurements need to be carried out, these can include some or all of the following:

- End-to-end optical link loss
- Rate of attenuation per unit length
- Attenuation contribution of splices, connectors and couplers
- Length of the fibre or distance to an event
- Linearity of fibre loss per unit length
- Reflectance or optical return loss (ORL)
- Chromatic dispersion (CD)
- Polarisation Mode Dispersion (PMD)
- Attenuation Profile (AP)

Other measurements such as bandwidth may also be performed.

Some measurements require access to both ends of the fibre, such as Tier 1 optical loss testing, others require access to just one, such as Tier 2 testing with an OTDR.

Field Testing of Fibre cables falls into three group: installation, maintenance and fault finding/rectification.

The following provides a summary of each of these topics, the exact details of which depends upon the system design and the contractual requirements as outlined in the Systems Specification as detailed by the Client or their representatives.

## Installation Testing

### Pre-Installation Tests

Prior to installation, perform fibre inspections to ensure that the cables received conform to the right specifications of the project (Category, Length and Attenuation) Also ensure that all connectors, pigtails and couplers, meet the requirements along with the end-face condition (particularly if pre-term assemblies have been supplied) have not been damaged in transit.

### Installation and Commissioning Tests

During installation ensure that the area involved with the termination of the fibre is kept clean at all times and prevent the introduction of dust and debris, as this will have a major impact on the quality of system that will be handed over.

Perform tests to determine the quality of cable splices and terminations including, end-face condition, attenuation, location and reflectance. Also carry out testing to ensure the installed system is suitable for the intended application. All these tests should be recorded and provided both to the customer as well as Excel Networking as part of the warranty application.

## Maintenance Tests

Maintenance testing involves periodic evaluation of the fibre cabling system to ensure that no degradation of the cable, splices or connections has occurred. The first stage of this should always be inspection of the end-face to ensure that no contamination has been introduced during the operation of the system. Other tests include cable attenuation along with attenuation and reflectance of splices and terminations.

It is the responsibility of the Client or their representatives to define the regularity of this testing.

## Fault Finding and Rectification

During fault finding and rectification perform testing to first identify the cause of the fault (transceiver, cable, connector, patch cord) as well as the location of the fault.

Once rectification has been successfully completed carry out testing of the repaired system following the guidelines covered in 'Installation and Commissioning Tests'.

# Combined Testing Methodology

## Testing Set-up

This element is designed to provide the installer with valuable information on how to set up the Fluke DSX 5000 correctly to provide Excel with the required information to assist us in processing the warranty applications smoothly and without undue delay. (The process differs only very slightly across other testers)

It is an easy to follow step-by- step guide for the less experienced whilst providing a useful reminder for those that have been testing for many years.

### Copper Testing

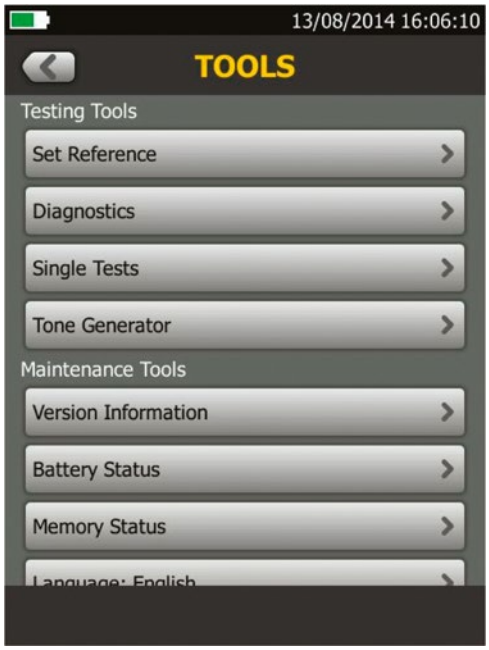
This will be broken down into a number of sub-topics, Permanent Link, Channel, Harness Links/Consolidation Cables and Patch Leads. A full description of what each one of these constitutes can be found in the diagrams in other sections.

However the first step is to check that your tester is fit for purpose, it has the right software and test limits loaded and has been calibrated correctly, this is a very simple process with the new Fluke DSX 5000 and shows when the device was last calibrated and the software revision. It is very simple to check on the Fluke Networks website at **www.flukenetworks.com** and download the latest version.

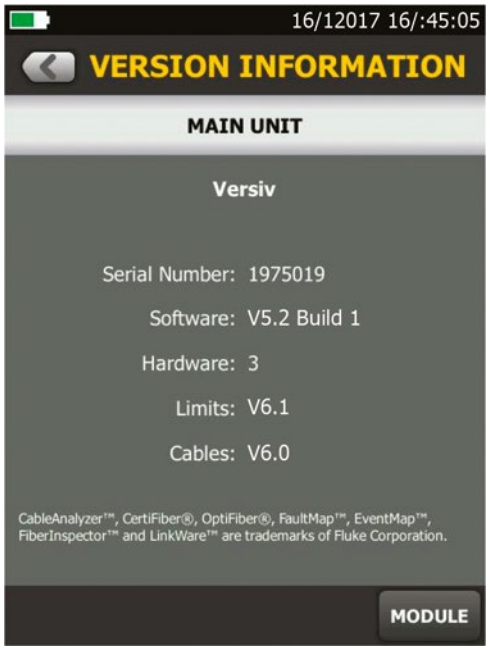
NB. As a Touch Screen interface you select by tapping on the icon involved.

On power up you will get the Home Screen (on the left) which shows how the device was set up for the last test. Tap the Tools icon to bring up that page.

NB. If you ever want to return to the Home Screen at any point you can press the HOME button on the front of the Main Unit.


Go into Tools once there select Version Information, within here you will be able to check both the Main Unit and the module that is fitted, whether that be Copper or Fibre.

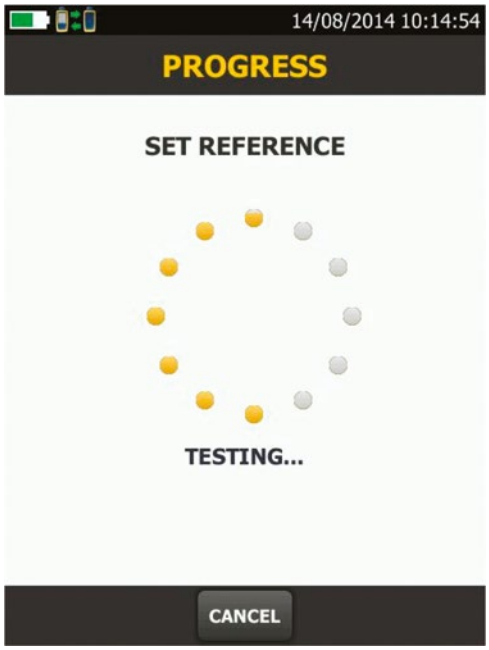



Within Tools you can also set up units of measure, language, date & time etc.

Following this you must reference the Main and Remote Units, again it is a very simple task, attach the PLA004 Permanent Link Adaptor to the Main and the Channel Adaptor to the remote. Plug them together.

Again within the Tools page select Set Reference you will then be guided through the simple process by the on screen instructions.


When ready, select the Test icon the unit will then run through the process, which only takes a few seconds and is recommended prior to starting every days testing.

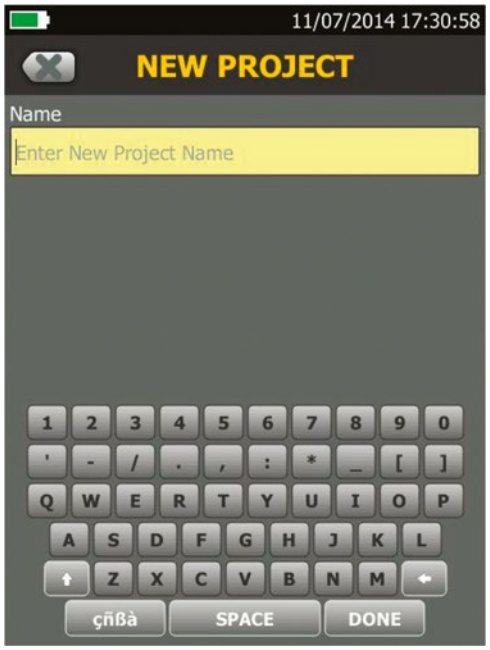



The next task is to set up the PROJECT INFORMATION. Once more this has been simplified and is even quicker to complete.

From the Home Screen select PROJECT, within this screen you will be able to see each of the topics that require input.


This screen not only allows for projects to be directly set up on the device itself as well as transferring pre-configured projects that have been set up within Fluke Linkware. However for this document we will concentrate setting the project up within the DSX 5000 directly.

From this screen select CHANGE PROJECT, you will then be prompted to either select an existing one or create a new one select CREATE NEW



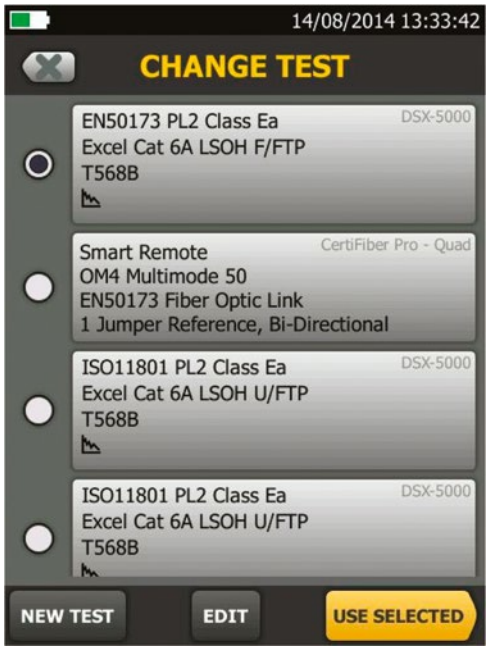

Repeat the process for OPERATOR, which allows for the selection from a list of previous users or the creation of a new one.

# Permanent Link

We now have to set up the specific test criteria needed for the project.

Once more this is very simple, as the unit senses whether the module attached is either Copper or Fibre and automatically selects a list of relevant tests. The Home Screen will show the last test carried out.

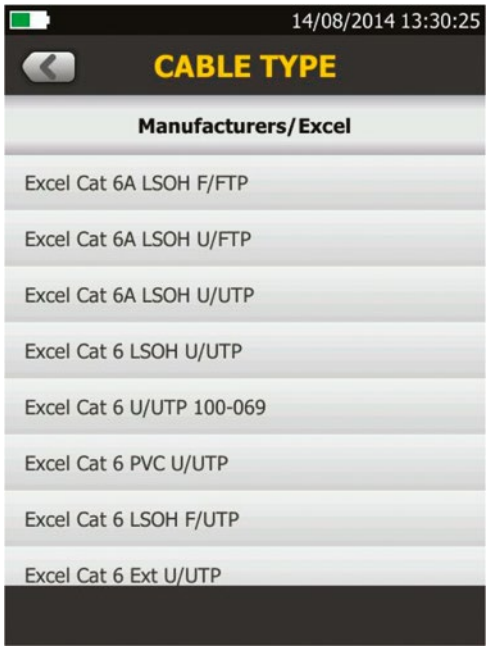
Select TEST which will bring up the details of the test and then you can either, select one from the list displayed, edit one from the list or create a new one. For this exercise select NEW TEST.




This will then bring up a new set of options.

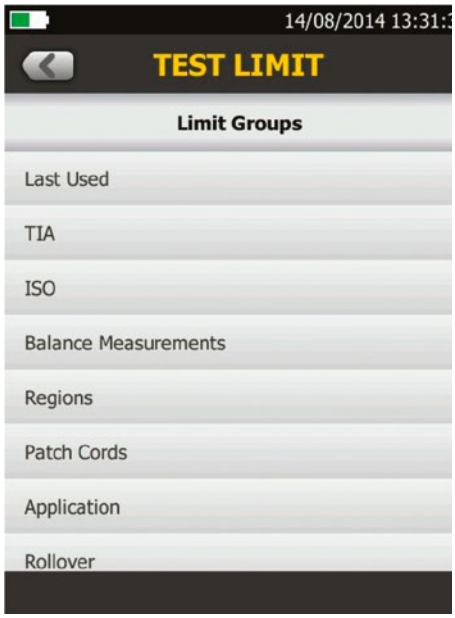

Again this initially brings up the previous test criteria for you to edit and amend

Select CABLE TYPE, This will initially bring up a list of previously used cable types, if the one that you want is not listed select more and then the Manufacturers tab and then scroll down to EXCEL as Fluke Networks and many other equipment manufacturers list the details of Excel cables within their testers.

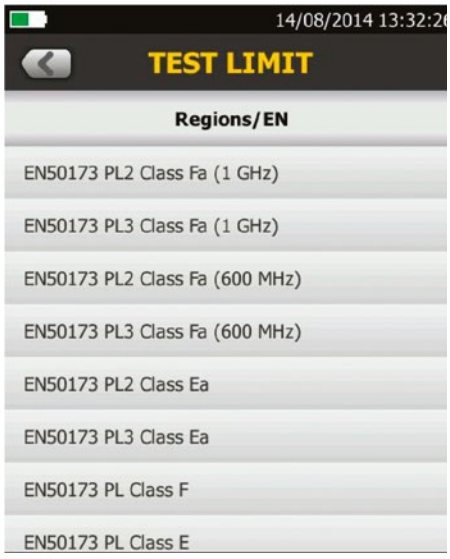



Select the type required, which inserts the relevant NVP etc and automatically takes you back to the previous screen. Follow the same process for selecting the required test limit.

However there is one slight anomaly in this process, by selecting TEST LIMIT it brings up a list of previously used tests, if the one required is not on the list, select MORE, which brings up the following screen, you will notice that it does not include EN (Cenelec).




You must first select REGIONS and then from within that screen EN, this will then bring up all the relevant Cenelec standards to be selected from.




For Warranty Application Purposes, EXCEL prefers that Cenelec test limits are used.

Also note at the higher Classes there is both PL2 and PL3 listed, ensure you select the correct one. PL3 is to be used whenever a Consolidation Point is part of the design.

The TEST SETUP Screen also allows contains two other important items that require selection they are:

STORE PLOT which must be selected as ON and HDTDR/HDTDX which must be set to FAIL/PASS*

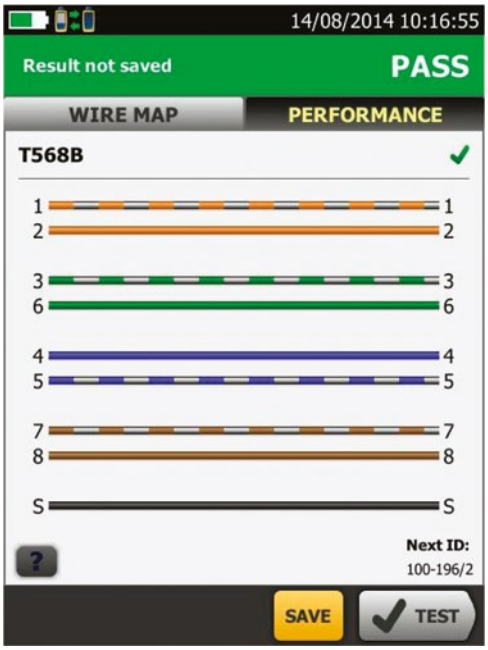
You are now almost ready to start testing but first of all you must select SAVE to store the information you have just created.

One final additional feature of the DSX 5000 is; within the Home Screen, you have the ability to set up the ID field for those links you intend to test, this can be done when setting up the project or at this stage simply by selecting NEXT ID: which brings up the next one in the range that was previously used. Select CHANGE CABLE Ids and then you can either edit the existing range or create a New ID Set within this last item you can even create a start and first point of the range.

Once you select DONE, it will take you back to the test you have set up

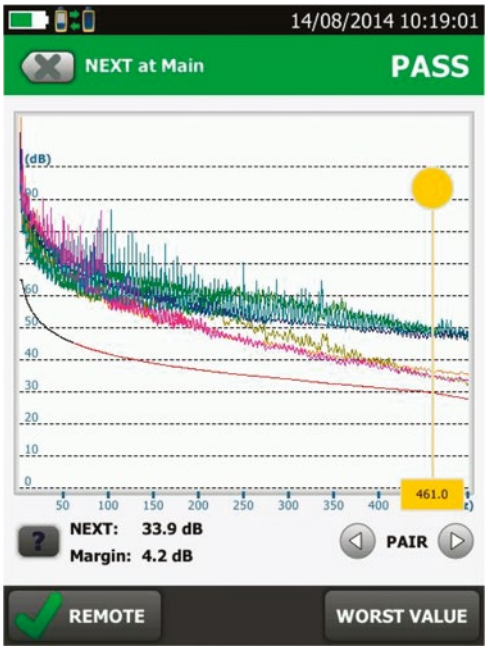
Attach the two PLA004 leads and testing can now commence testing.

Either by pressing the White Button on the front or selecting TEST from the Home screen. It is a remarkably quick process. And the first screen you should see is the PASS screen, which has two tabs the first being WIRE MAP the second being the PERFORMANCE





To see an individual result just select the parameter and it will bring up the next screen.





You then have the option to view either from the Main or Remote end as well as seeing Worst Values, you can scroll each of the Pairs along with being able to drag and drop the cursor to specific frequencies, even zooming in a similar way as you do on any Smartphone.

# Channel

Channel Testing is not to be used for Warranty Applications, these guidelines are designed for troubleshooting purposes only.

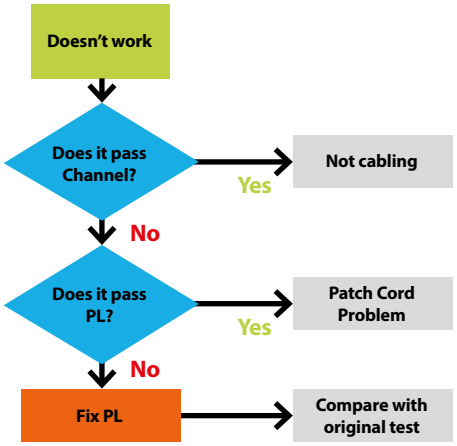
Testing the channel is very simple and straightforward.

Replace the Permanent Link Heads and replace them with the Channel Heads, and following the guidance previously given in this section, select a new set of patch leads to be used as reference cords, they should also be a minimum of 2m in length.

NOTE: these Reference Cord/Patch Leads should be replaced with new ones after every 100 tests.

From the Home Screen select the relevant Channel test in the same manner as described previously and select TEST.

The following is a workflow diagram for troubleshooting.

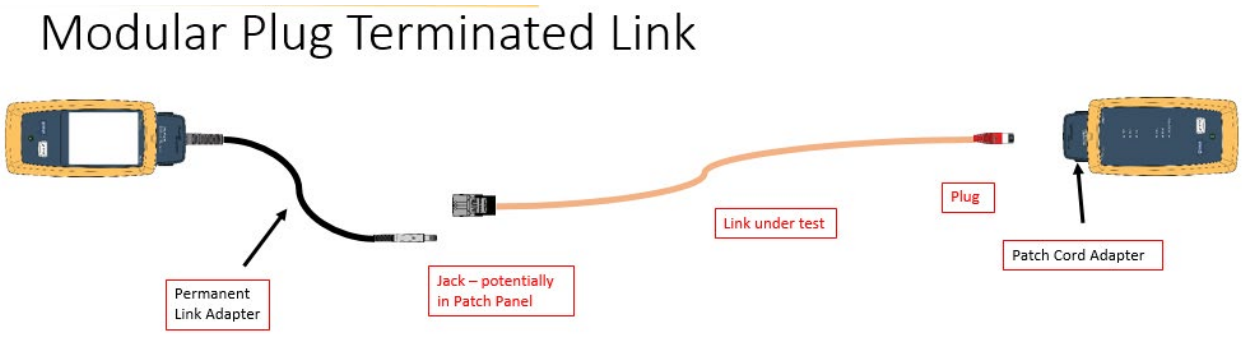


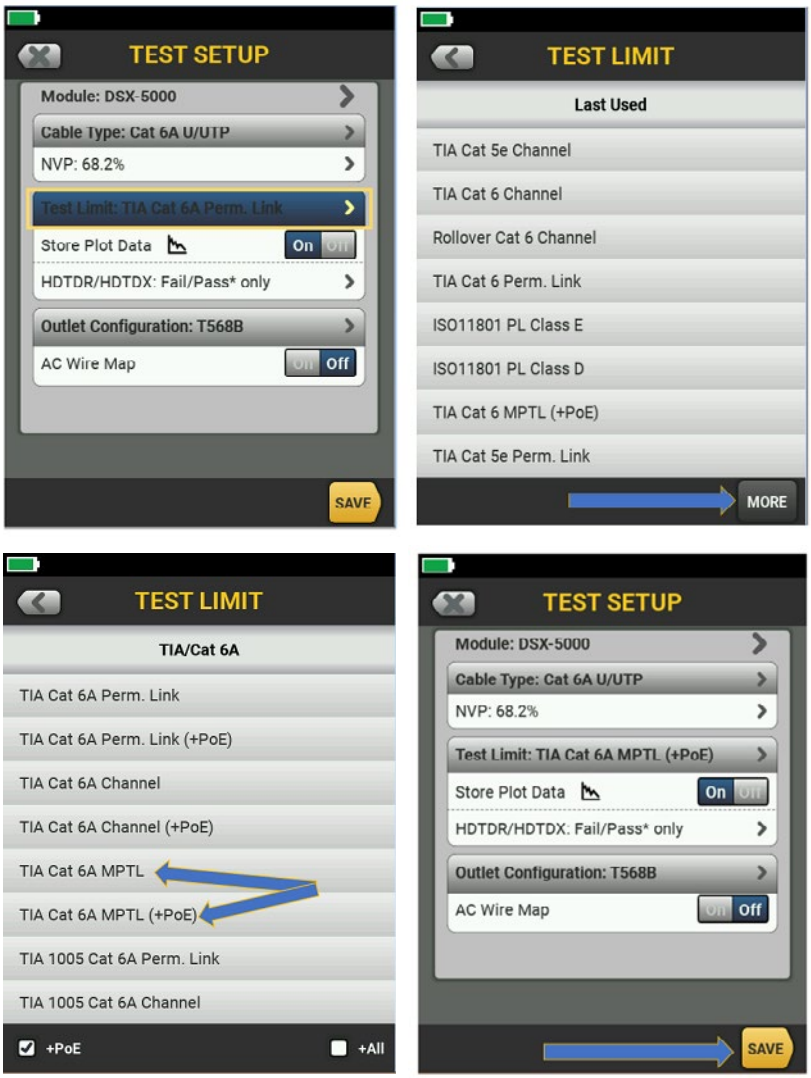

# Modular Plug Terminated Link (MPTL)

NEW for V5

The new test is called the MPTL (Modular Plug Terminated Link). At the time of writing this test model was first ratified by EIA/TIA, ISO/IEC have just approved their limits in ISO 14763-4 Ed2. And that should be published in the next couple of months and Cenelec will follow in due course in the next few months.

This test method requires the use of a Patch Lead test head at the remote end to ensure the value of the RJ45 termination is included in the result, with the DSX as can be seen from the screen grabs below it is also possible to detect whether PoE is present. It is a straightforward process to set up the test.






Until the ISO/IEC test limits are published and loaded into the next release of firmware by the test equipment manufacturers, Structured Cabling manufacturers will be issuing an EIA/TIA warranty on those specific links. If the client insists on an ISO 11801 warranty, there is a way of recertifying those results, but it does require a level a level of manual interpretation of the results which is not ideal.

# Patch Leads

The purpose of certification testing is to ensure that a link, channel, or component meets industry performance standards. Installers certify permanent links and the network owners install patch cords at a later date to complete the channel.

Patch cord certification brings together a compliant permanent link and patch cord to make a standards compliant channel. Patch cord certification can be performed in the factory or the field with the right Test Equipment and Adapters.

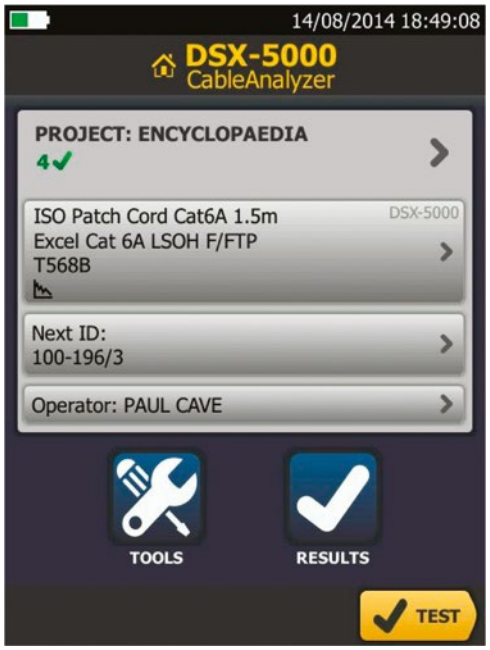
As with permanent links and channels, the test equipment used for certification must be set to the correct test limit and the relevant category Patch Cord Test Heads are used.

- Image features Category 6 Patch Cord Adapters

The Fluke Networks has a range of Patch Cord Test Head Sets available, Cat5e, Cat6 and Cat6$_A$ They all come in a version that can test both Screened and Unscreened cables. Also note unlike the Permanent Link and Channel Adaptors, they are Specific Main and Remote Heads, check you have them the correct way around as the DSX will warn of an incorrect set up.

From the Home Screen select a new Test Limit as has been described in this document, this time select Patch Cords, this will then bring up all the Categories.


Select the required length and then SAVE, and select from the list and you can start testing.



# Fibre Testing – (Tier 1)

Excel requires Fibre testing to be carried out using a Power Source and Light Meter, sometimes referred to as Fibre Loss Testing, this should be completed using the One Jumper Reference Method, the following section will guide you through what is required and how to set up a Fluke DSX 5000 fitted with Certifber Quad Fibre Modules for Multimode testing, if you testing Singlemode or using any one of the other authorised testers please refer to the Test Equipment Instruction Manuals.

We suggest that you carry out the complete set up prior, to attaching the launch leads and referencing the two units. A lot of people shy away from fibre because they think it is difficult, however from the following you will actually see how simple and easy it really is.

Carry out of setting up the PROJECT INFORMATION as outlined in the Copper Section

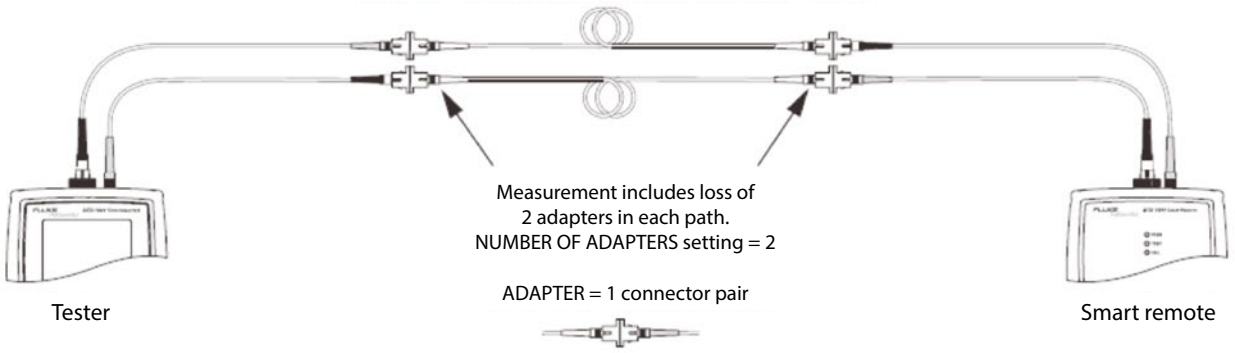
However as soon as you attached the Certifiber Modules the DSX 5000 is intelligent enough to recognise this and starts part of the process for you as at the top of the Home Screen it shows the modules fitted.


Select TEST LIMIT and you will have a number of options, once more we want to select the EN50173 Standards, if it isn't in the LAST USED list use the same process as previously described.

You will then have to change some of the other settings, ensure that Test type is SMART REMOTE and Bi-Directional is ON. Fibre Type is correct

The next stage is one of the most important during the set up phase, enter incorrect information at this stage and you WILL get incorrect results, you are setting up the 'Loss Budget' for the link you are about to test, get this wrong and successful passes will be reported as failures.

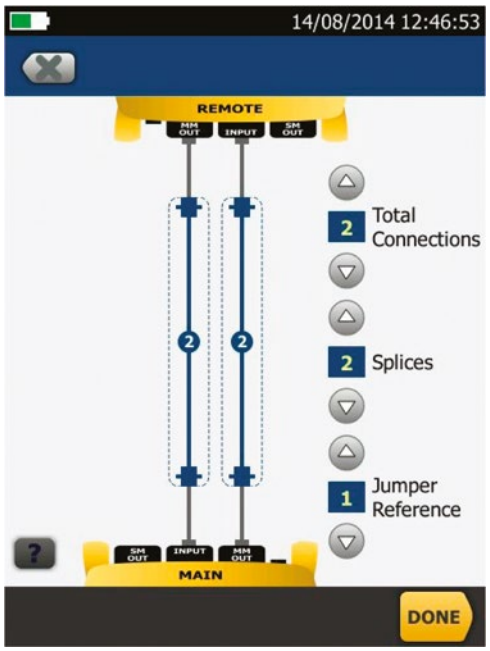
**Example of Smart Remote mode test connections**




You must therefore enter the correct number of Adaptors in your link as well as the correct number of Splices, (within Patch Panels etc.)

Underneath the Test Limit on the TEST SETUP Screen, there are 3 settings: Reference Method should always be 1 Jumper.

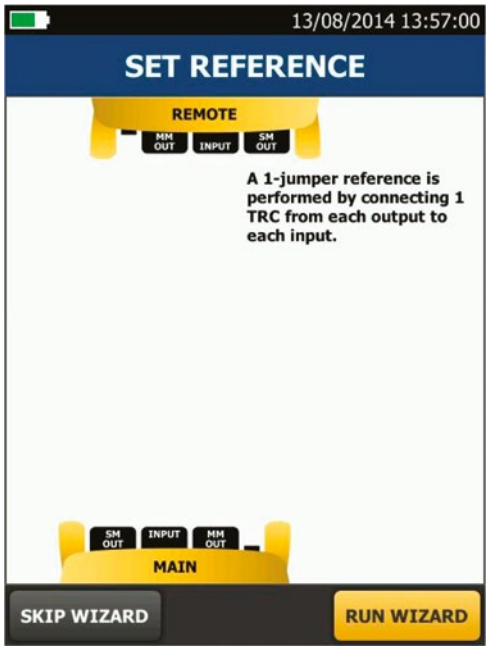
The next is the Connector Type the last one covers the number of Connections/Splices, select this and it will bring up the next screen.



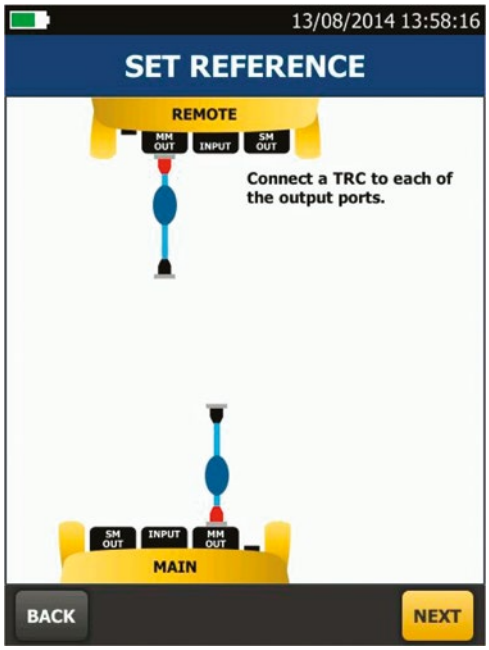

Once you have selected the right number for each item select DONE and you will be taken back to the TEST SETUP screen.

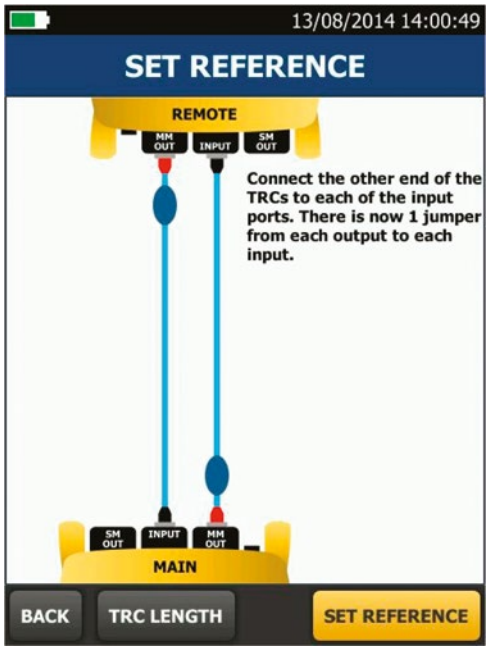
The final part of the setting up the test is to Reference the Fibre Test Leads. Select HOME, when the Home Screen appears; Select the additional icon SET REF.

This brings up the SET REFERENCE Screen, which provides two options.

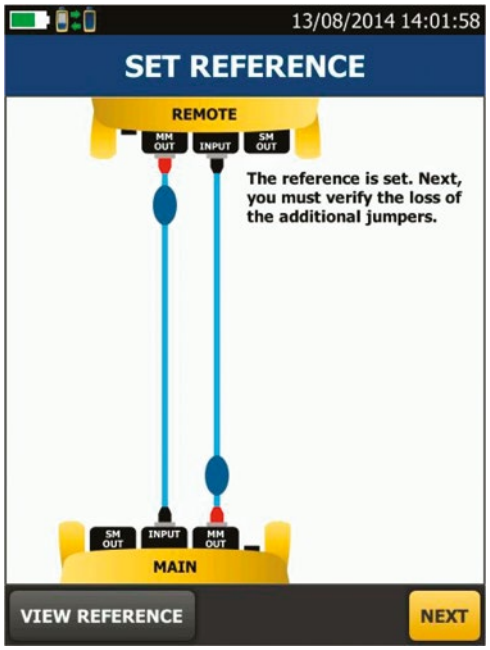


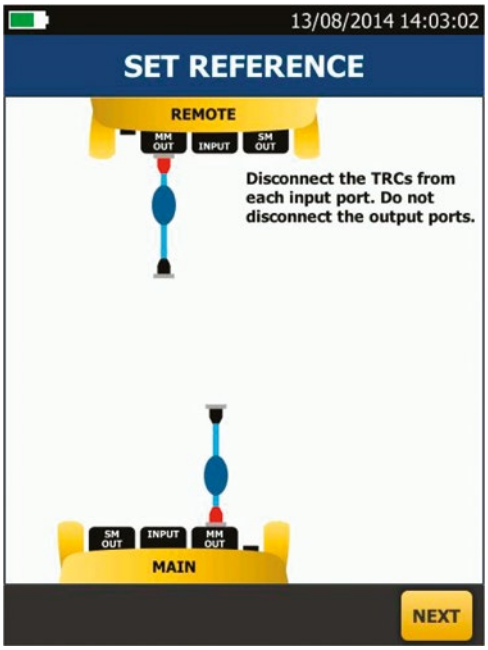

To ensure that you complete this important phase correctly select RUN WIZARD, this will take you through all the steps required.



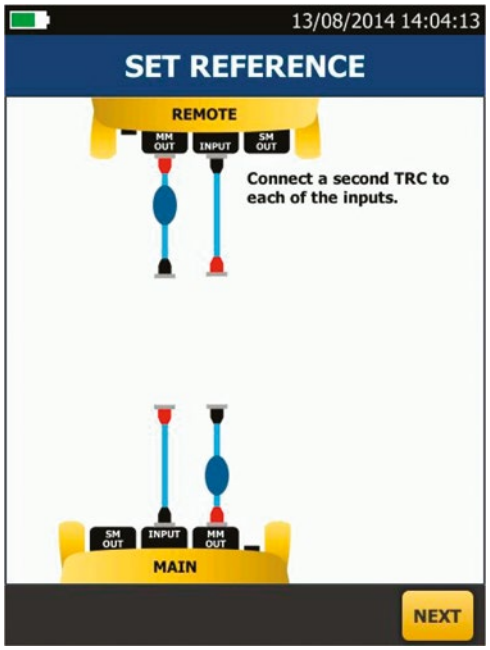



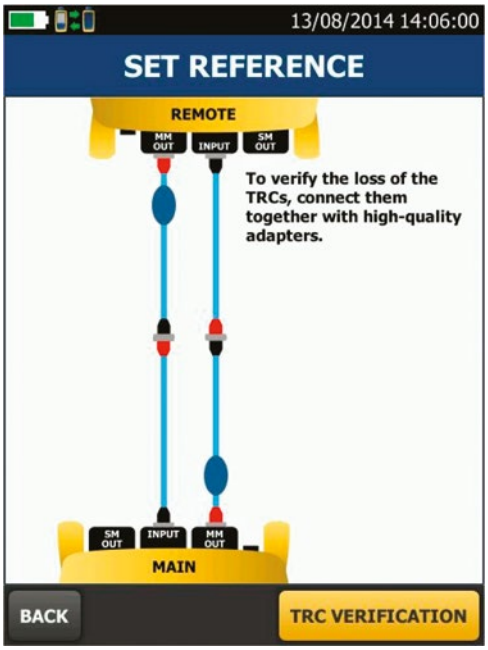

Once the units are connected Select SET REFERENCE



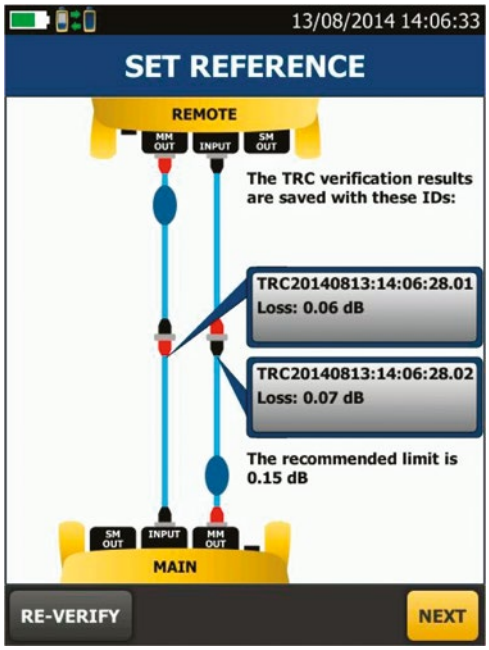



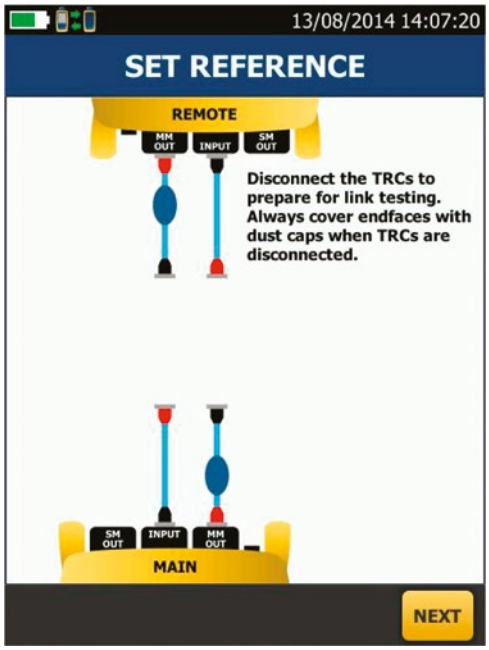

After each step select NEXT

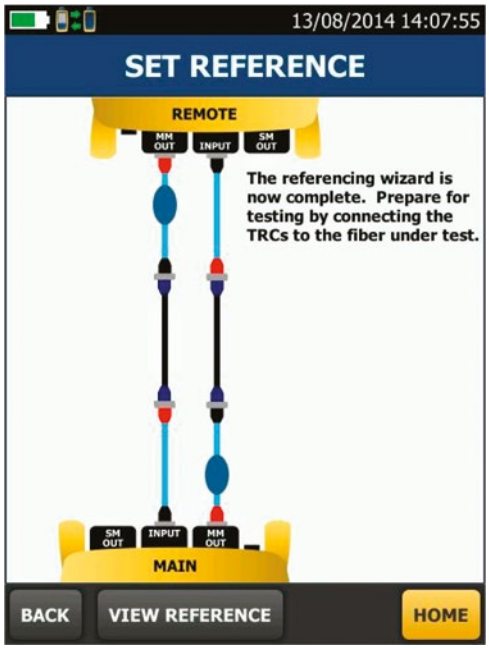



Select TRC VERIFICATION, this brings up the values of the leads that have been Referenced Out.




By selecting HOME it takes you back to the Home Screen, once there quickly verify the details and you are then ready to start testing.

You are now ready to start testing the fibre links. The process for setting up to Singlemode Links is almost identical.

If there are any doubts on how to set up you tester for a specific project it is recommended that you call Excel Technical Support, prior to commencing to avoid any confusion and delays with warranty applications at a later stage.

# Permanent Link Description

A Permanent Link is defined as the cabling between two outlets (or three outlets if a Consolidation Point (CP) or Local Distribution Point (LDP) is used) but excludes any patch cords.

A Permanent Link, is the fixed cabling, to which equipment and work area cords are added to complete the channel (see diagram below). Physically the Permanent Link includes cable and outlets (possibly presented in a patch panel). Where a CP or LDP is required in the Permanent Link the CP or LDP to Outlet cord and the outlet are to be included in the Permanent Link measurement and testing. There are limits imposed within the standards for key electrical parameters such as STET, insertion loss, NEXT, RL, PSACR-F etc. The horizontal PL must take into consideration all elements necessary to configure the operational channel, which has a limit of 100m (305ft).

## Channel Description

A channel is defined as the "up to 100m" connection between two active components.

Physically the channel includes horizontal cable outlets (possibly a patch panel), Interconnect (fan out cables) and any cross connect (patch cords), equipment or work area patch cords. There are limits imposed for key electrical parameters such as insertion loss, NEXT, RL, PSACR-F etc, the channel is not limited to a maximum of 4 connectors or junctions. However should a channel configuration require more than 4 connectors then approval must be given, at design stage, by Excel for their warranty support.

Testing of a channel can take two forms:

- Confidence test where the patch cords are removed or replaced following the test
- Full test where the final configuration is tested and left in place

A channel test serves to validate either conformity with the generic cabling standards or application support.

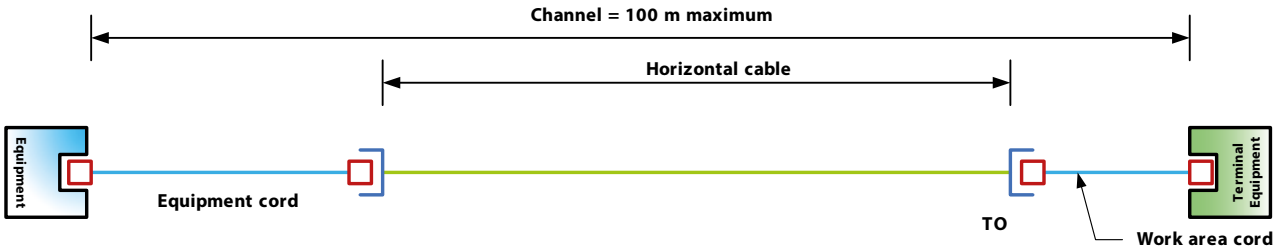
The term "Reference Cord" is defined here as a new Excel patch cord that will only be used for up to 100 tests. After 100 tests the Reference Cord must be destroyed and replaced with another new Excel Reference Cord.

Before a Channel test is performed all components in the Permanent Link must have been configured and validated for component compliance.

Marginal or star passes on all other criteria are to be treated as failures.

# Typical Permanent Link & Channel Connectivity Models

## a) Interconnect – TO model




### Mandatory tests:

| Element | Test | |
|---|---|---|
| Permanent Link | Permanent Link |  |

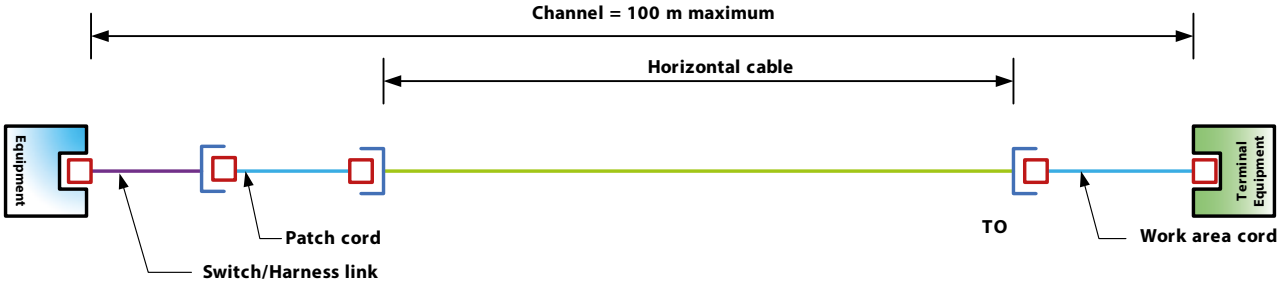


### Optional tests:

| | | |
|---|---|---|
| Channel | Channel |  |



## b) Crossconnect – TO model




### Mandatory tests:

| Element | Test | |
|---|---|---|
| Permanent Link | Permanent Link |  |

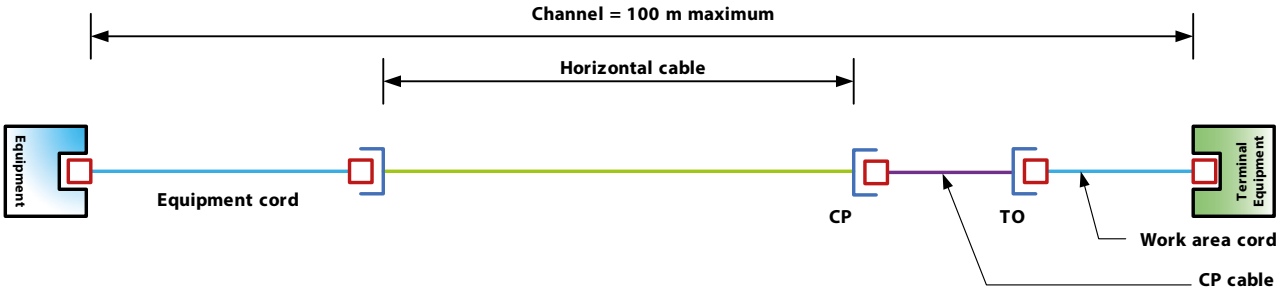


| | | |
|---|---|---|
| Switch / Harness Link | Permanent Link (PL head to Ch head) |  |

### Optional tests:

| | | |
|---|---|---|
| Channel | Channel |  |

## c) Interconnect – CP - TO model




### Mandatory tests:

| Element | Test | |
|---|---|---|
| CP Link | Permanent Link |  |
| CP Cable | Permanent Link (PL head to Ch head) |  |

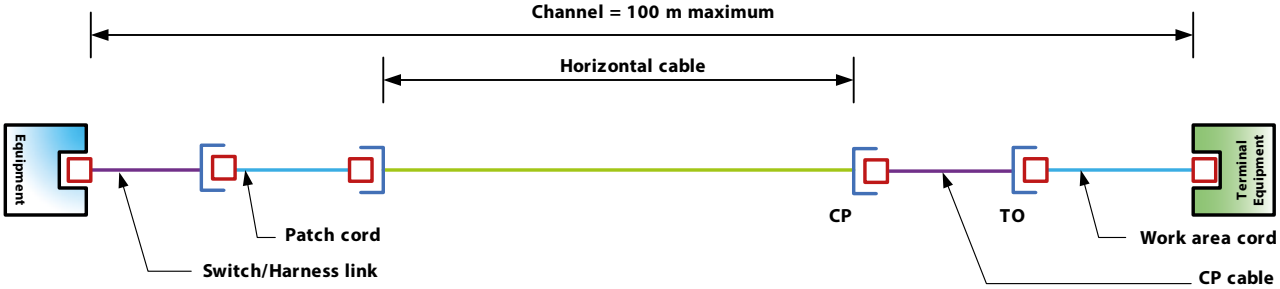


### Optional tests:

| | | |
|---|---|---|
| CP Link - TO | Permanent Link |  |
| Channel | Channel |  |



## d) Crossconnect – CP - TO model




### Mandatory tests:

| Element | Test | |
|---|---|---|
| CP Link | Permanent Link |  |
| CP Cable | Permanent Link (PL head to Ch head) |  |
| Switch / Harness Link | Permanent Link (PL head to Ch head) |  |



### Optional tests:

| | | |
|---|---|---|
| CP Link - TO | Permanent Link |  |
| Channel | Channel |  |

# 16 million

The number of single-use plastic bags we save each year with our plastic free packaging initiative.

At Excel Networking Solutions, we were the first in the industry to have taken steps to supply products in #plasticfree packaging. By switching to "natural" packaging options for all our Excel patch leads and keystone jacks and numerous other Excel products we are reducing our annual single-use plastic bag usage by 16 million bags.

## Are you keen to help the environment?

**#BreakFreeFromPlastic #DoYourBit #Choose Excel**

S19

ZERO Plastic Packaging

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