

University Of Warwick
Telecommunications Cabling
Specification
ITS-SJS-TCS/V6.1

Revision History

No	Date	Note
001	13/07/06	Initial issue
002	29/10/06	Sections 2 updated
003	13/03/07	Section 6 updated comms cabinet
004	02/04/08	Brand-Rex part numbers added.
005	29/11/10	General update
006	12/01/12	Minor Updates (DGB)
007	19/05/14	General update of all sections to version 6.1

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1. Telecommunication Cabling overview

The purpose of this document is to enable the planning and installation of Telecommunications cabling and associated systems of the BELDEN, BRAND-REX and R&M Cabling Solutions within any location at the University of Warwick, to ensure that all newly installed systems are compatible with current standards and expected future applications

Readers must note the University of Warwick accepts no liability for part numbers specified in this document. Readers shall satisfy themselves via direct contact with the relevant manufacturers, applicable, that the part numbers are relevant to the textual descriptions given. The textual descriptions will override any part number

For example, if a specification calls for a 5m blue patch cord and supplies a relevant part number but the part number is for a yellow patch cord then the textual description shall 'override' the part number and the quotation submitter must obtain a correct part number from the manufacturer

Unless otherwise stated, all telecommunications cabling works are carried out by the University of Warwick preferred installer, Dimension Data Advanced Infrastructure.

Dimension Data have entered a five (5) year frame work agreement with the University of Warwick commencing on the 9th March 2009.

Dimension Data contact details are as follows:

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1.1 Standards & Specification detail

The complete system must be planned & installed in accordance with the following standards where applicable and where practicably possible:

ISO/IEC JTC1

- ISO/IEC 11801 Ed.2:2002, Information Technology—Generic Cabling for Customer Premises
- ISO/IEC 14763-1:1999, Information Technology—Implementation and Operation of Customer Premises Cabling—Part 1: Administration.
- ISO/IEC TR 14763-2:2000, Information Technology—Implementation and Operation of Customer Premises Cabling—Part 2: Planning and Installation of Copper Cabling.
- ISO/IEC TR 14763-3:2006, Information Technology—Implementation and Operation of Customer Premises Cabling—Part 3: Acceptance Testing for Optical Cabling.
- ISO/IEC 18010:2002, Information Technology—Pathways and Spaces for Customer Premises Cabling

- CENELEC EN 50173, Information Technology—Generic Cabling Systems, 2006
- CENELEC EN 50173, Information Technology—Generic Cabling Systems—Amendment to Clauses 2, 3, 5, 6, 7, 8 and Annexes A, B, H of EN, 2000.
- CENELEC EN 50173-1, Information Technology—Generic Cabling Systems—Part 1: General Requirements and Office Areas (work in progress).
- CENELEC EN 50173-2, Information Technology—Generic Cabling Systems—Part 2: Industrial Premises (work in progress).
- CENELEC EN 50173-3, Information Technology—Generic Cabling Systems—Part 3: Small Office Home Office (SOHO) (work in progress).
- CENELEC EN 50174-1, Information Technology—Cabling Installation—Part 1: Specification and Quality Assurance, 2009
- CENELEC EN 50174-2, Information Technology—Cabling Installation—Part 2: Installation Planning and Practices inside Buildings 2009.
- CENELEC EN 50174-3, Information Technology—Cabling Installation—Part 3: Installation Planning and Practices Outside Buildings 2003
- CENELEC EN 50310, Application of Equipotential Bonding and Earthing in Buildings With Information Technology Equipment, 2006.
- CENELEC EN 50346, Information Technology—Cabling Installation—Testing of Installed Cabling, (Draft.)

UK Codes & Standards

- BS 6701, Code of Practice for Installation of Apparatus Intended for Connection to Certain Telecommunication Systems, 2004
- BS 7430, Code of Practice for Earthing, 1998.
- BS 7671, Requirements for Electrical Installations. IEE Wiring Regulations, 2008
- BS 7718, Code of Practice for Installation of Fibre Optic Cabling, 1996.

ANSI/TIA/EIA produces several documents and standards that affect telecommunications.

- ANSI/TIA/EIA-526-7-98, OFSTP-7—Measurement of Optical Power Loss of Installed Single-Mode Fibre Cable Plant, 1998
- ANSI/TIA/EIA-526-14-A-98, OFSTP-14—Optical Power Loss Measurements of Installed Multimode Fibre Cable Plant, 1998
- ANSI/TIA/EIA-568-B.1, Commercial Building Telecommunications Cabling Standard, Part 1: General Requirements, 2001.
- ANSI/TIA/EIA-568-C.0 Generic Telecommunications Cabling for Customer Premises Feb 2009
- ANSI/TIA/EIA-568-C.1, Commercial Building Telecommunications Cabling Standard, Feb 2009
- ANSI/TIA/EIA -568-C.2 Balanced Twisted Pair Telecommunications Cabling and Components Standard. August 2009
- ANSI/TIA/EIA-568-C3, Optical Fibre Cabling Components Standard, June 2008
- ANSI/TIA/EIA-569-B, Commercial Building Standards for Telecommunications Pathways and Spaces, 2003
- ANSI/TIA/EIA-598-B, Optical Fibre Cable Colour Coding, 2001.
- ANSI/TIA/EIA-604.2, FOCIS 2—Fibre Optic Connector Inter-mate-ability Standard, 1997.
- ANSI/TIA/EIA-606-A, Administration Standard for Commercial Telecommunications Infrastructure, 2002
- ANSI J-STD-607-A, Commercial Building Grounding (Earthing) and Bonding
- ANSI/TIA/EIA-758, Customer-Owned Outside Plant Telecommunications Cabling
- ANSI/TIA/EIA-758-1, Customer-Owned Outside Plant Telecommunications Cabling
- ANSI/TIA/EIA-854, a Full Duplex Ethernet Specification for 1000 Mb/s (1000BASE-TX) Operating over Category 6 Balanced Twisted-Pair Cabling, 2001
- This document specifies a 1000BASE-TX PHY layer as defined in the ISO/IEC Open Systems Interconnection (OSI) reference model.
- TIA/EIA TSB-125, Guidelines for Maintaining Optical Fibre Polarity through Reverse-Pair Positioning, 2001
- TIA/EIA TSB-140, Additional Guidelines for Field-Testing Length, Loss and Polarity of

2. Horizontal Distribution Systems.

Definition

Horizontal distribution systems comprise of two general sections, pathways and spaces and cabling systems.

Pathways and spaces are used to contain, support, distribute and provide access to the horizontal cabling from a telecommunications room (TR) to the work area (WA).

Pathways and spaces include:

Physical pathways such as conduit, tray and trunking etc.

Non-physical pathways such as the space between open cable supports.

Transition and consolidation points.

Horizontal cabling systems are the means by which signals are transmitted between the work area (WA) and the floor distributor (FD) in the telecommunications room (TR), i.e. the cables and connectors.

Horizontal cabling systems include;

Telecommunications outlets in the work area and/or MUTOA's

One optional consolidation point.

Horizontal cable.

Mechanical terminations.

Patch cords used to configure horizontal cable connections that comprise the floor distributor.

2.1 Horizontal Pathways and Spaces.

The design of the horizontal containment system or pathways and spaces should take into account the following considerations;

Allow for potential future growth.

Provide suitable protection for the cables in the pathway environment.

Provide a neat and serviceable appearance when in visible locations.

Accommodate future additional containment.

Provide as much protection from EMI as practicable.

As a general rule of thumb all containment systems **shall be** designed with 50% expansion capacity.

MKs Prestige 3D range of dado trunking and accessories or similar, is preferred for containment within office areas as this provides the correct environment for the installation and termination of CAT6 telecommunications cabling.

2.2 Sizing.

The sizing of pathway systems can generally be determined from the manufacturer guidelines, governing fill factors and weight considerations. These should be closely studied as part of the design process.

Manufacturers sizing tools and software may be used to assist with sizing calculations.

UTP and FTP are generally 4-6mm in diameter, 4-core indoor fibre cable 3-6mm and STP 8-11mm depending on manufacturer.

Sizing of tray and conduit is a complicated task and manufacturer's guidelines should be followed. Fill calculation depend on the number and diameter of cables.

However, for information purposes ONLY, the following simple guidelines can be followed.

Conduits, where 1 cable is installed the max fill ratio is 53%, 2 cables is 31% and 3 or more cables 40%.

20mm conduit, No more than 2 x CAT6 telecommunications cables to be installed.

25mm conduit, No more than 4 x CAT6 telecommunications cables to be installed.

32mm conduit, No more than 8 x CAT6 telecommunications cables to be installed.

Basket tray, 50% fill ratio is allowed for open cable tray.

Each 90 degree bend reduces the conduit capacity by 15%, gusset or fillet bends are required on all bends exceeding 45 degrees radius

What size trunking is needed for 30 cables?

Cable diameter = 6mm

Cable CSA = $\pi r^2 = 3.142 * (3 \times 3) = 28.5\text{mm}^2$

Number of cables x CSA = $28.5 \text{ mm}^2 \times 30 = 855\text{mm}^2$

50x50mm trunking, CSA = $50 \times 50 = 2500 \text{ mm}^2$

40% fill factor = $2500 \times 0.4 = 1000 \text{ mm}^2$

Therefore this size trunking would be sufficient for the 30 cables but would not satisfy the expansion requirements i.e. 50% extra cable or 45 cables. The next size up would be required

2.3. Suspended Ceilings and Raised Floors.

For installations involving 7 or more horizontal cables suitably sized basket tray or conduit systems shall be installed in suspended ceiling spaces, where they form part of the route, unless there are already installed systems, which may be utilized. For installations involving less than 7 cables, cable hangers (J-hooks) and other similar systems may be used.

All installations utilizing raised floors shall have a suitably sized containment system installed in the floor void with a 3 meter tail, unless there are already installed systems, which may be utilized.

Containment systems in ceiling voids shall be fixed independently of the ceiling fixtures and cables shall not be allowed to rest directly on the ceiling tiles or fixtures.

2.4. Hangers and Suspension Fittings

Where a small number of cables (less than 7) are to be contained within a ceiling void or other such open area, then they may be supported with plastic cable supports and girder cleats.

Care shall be taken to ensure that the allowed bend radius of the contained cable is maintained and that ties are not over tightened leading to cable deformation

2.5. Ties, Wraps and Grommets.

Nylon/Plastic tie wraps **cannot** be used to secure bundles of CAT6 cables. This includes during the installation phase of the telecommunications cabling. Velcro cinch ties or wraps shall be used. Care shall be taken to ensure that cables are not damaged due to over tightening.

Cables shall be secured in bundles of no more than 24 in all cases.

Specifically, when cables are contained in horizontal basket tray they shall be loose laid except at any change of direction where they shall be tied in bundles of no more 24 cables and secured to the basket.

When contained vertically on any type of cable tray they, shall be tied in bundles of no more than 24 cables at appropriate distances.

Where cables enter metal boxes, ducts or through similar apertures then the edges shall be covered with suitable grommet edge or circular grommets.

2.6. Cable Dressing.

It is understandable to equate absolutely parallel and neat cable dressing with 'good' installation practice, however given the installation constraints of high performance cable systems a degree of non- uniform cable dressing when in open containment systems is preferable.

Wherever possible cable shall be laid in rather than pulled.

2.7. Back Boxes.

Standard PVC back boxes for surface or recessed mounting shall be used; either double or single gang depending on the project requirements.

In order to provide as much internal space as possible, as a minimum 32mm back boxes shall be used. The use of extension collars are not permitted, unless the outlets are being installed in existing containment which 32mm back boxes cannot be fitted.

Perimeter trunking will require back boxes to be selected from the relevant manufacturer's product portfolio and spacing collars may be required in order to support the maximum allowed bend radius of the installed cable.

In general back boxes shall be fitted at the same height as existing outlets or power sockets but in a new installation the bottom of the outlet shall be installed no less than 375mm from the floor & within 100mm of a 240ac Power socket

2.8. Fire Stopping

In most cases fire stopping will be carried out by the main contractor and will fall under certain building regulations. However, where telecommunications cables pass through walls or slabs which need to keep a fire rating integrity, products such as the Abesco cable transit system or Cablofil EZ Path or any equivalent should be used to allow ease of future works and maintenance, whilst ensuring that the fire protection integrity is kept.

These products should be sized accordingly to allow the same amount of spare capacity as the cable highway that the telecommunications cabling is installed on.

Under no circumstances should any telecommunication cable be sealed with a fire stopping material that comes into contact with the cable sheathing, for example, putties, foam and decorating sealant (also paint) as this may invalidate the 25 year performance warranty and also cause issues for future expansion and maintenance.

Examples of approved fire stopping barriers.



CT120 Cable
Transit

Part of the 'Abesco fire clamp system', CT120 Cable Transits are designed to prevent the spread of fire from one compartment to another where electrical, data, and communication cables penetrate through separating walls and floors.



CT120/R Cable
Transit

Part of the 'Abesco fire clamp system', CT120/R Cable Transits are designed to prevent the spread of fire from one compartment to another where electrical, data, and communication cables penetrate through separating walls and floors.



CT240 Fire clamp Suitable for large openings and cable trays, the CT240 product is the largest of their fire clamp devices.

3. Horizontal Copper Systems.

3.1 Topology and General Design Issues.

Horizontal cabling systems can be used for the following services:

Voice, data, VoIP systems, BMS, Emergency lighting, PV systems, metering, Security, Audio visual and is being used more and more by developing systems.

They are always physically wired in a star topology although for some applications active equipment may convert this into a logical ring or bus.

Each work area (WA) outlet shall be wired directly to a floor distributor (FD) in the telecommunications room (TR). Horizontal cabling systems shall have a maximum length of 90m.

3.2 Category 6 Belden CDT System 2400, Brand-Rex Structured Cabling Systems and R&M Cabling Solutions

All installed telecommunications cabling will be either from the Belden/CDT 2400, Brand-Rex or the R & M Cabling Solutions CAT6 product range. This will be specified by IT Services prior to works going out to tender.

Product	Belden	Brand-Rex	R&M
Cat6 Patch Panel	AX101611	C6CPNLU24012M	305117
Cat 6 UTP LZH	CDT/400	C6U-HF1-RLX	809796

4. Installation Guidelines.

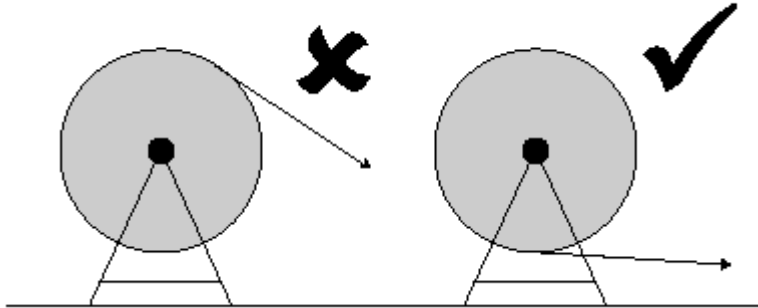
4.1. Twisted Pair Cable

Twisted pair cable is susceptible to excessive pulling tensions and therefore the manufacturers specified pulling tensions shall be carefully adhered to. It is noted that it is very difficult to accurately measure pulling tensions in the field but approximation can be made. The maximum pulling tension of a typical twisted pair cable is 111n or about 25lb. Cables shall not be pulled through more than 2, 90-degree conduit bends without using a pull box, slip sleeve or other similar space. Round conduit (besa) boxes are not to be used under any circumstances. When pulling twisted pair cables the maximum bend radius is 8x the outside diameter and when installed the maximum bend radius shall be 4x the cables outside diameter. (Consult manufacturer's guidelines).

Care shall be taken to ensure that during installation cable is protected from other trades and water ingress. If any cable is found to be damaged either during or post installation, the cable shall be replaced.

Care shall also be taken when pulling cables around corners etc. to ensure that no undue stresses are placed on the cable.

When pulling drums of cable they shall be supported on cable jacks or rollers. Cables should be pulled from the bottom of the drum.



300mm re termination slack shall be formed at the TR end of the link and 300mm re termination slack at the outlet, It is recognized that the TO re termination slack may not be possible directly at the TO but should be placed as close to the TO as is practicable. The order of termination and cable routing at the outlet termination shall be in line with manufacturer's recommendations.

4.2. Electrical Segregation.

The minimum segregation distance between unscreened electrical and unscreened telecommunication cables shall be 75mm; this applies to telecommunication cables of up to 90m total length and up to 10 240V AC, 20amp, 50/60Hz single-phase circuits.

A single three phase 415V AC circuit would account for three of the power cables as defined above.

A minimum of 130mm separation from fluorescent lights shall be maintained.

Where power and data cables cross they shall use a 'bridge' data cables on top and cross at 90 degrees.

5. Work Areas.

5.1. Definition.

A work area includes telecommunications outlets mounting hardware and patch cords. In general a work area is 10m² and this shall have a minimum of 2 x TO (work area outlets), however it is recommended that a minimum of 3 x TOs are installed per work area. The size of work area may vary from location to location along with TO count.

5.2 Cat6 Cabling system outlets

Unless otherwise stated new outlets shall comply with the following specifications.

UK Style surrounds, single or double gang, straight edged from the BELDEN/CDT, Brand-Rex or R&M portfolio. Part numbers are as follows:

Product	Belden	Brand-Rex	R&M
Single Gang	AX101373	MMCWDOUNI030LO	TBC
Double Gang	AX101374	MMCWDOUNI031	TBC

Outlets shall be BELDEN/CDT, Brand-Rex or R&M UTP jacks with either a flush or angled white shutter.

A flush shutter shall be used for all low level outlets, i.e. skirting trunking and an angled shutter shall be used for all dado, high level and floor-box mounted outlets. Part numbers are as follows:

Product	Belden	Brand-Rex	R&M
Flush Shutter	AX101375	MMCWDOUNI062	TBC
Angled Shutter	AX101376	MMCANG0623	TBC
Module	AX101065	C6JAKUOK3	305114

Where only a single outlet is installed in a double faceplate then a blank insert shall be used of the same RAL number as the faceplate.

No modification is to be made to the wiring of the terminated RJ45 jack. And any adaptor must be installed outside the faceplate, plugged into the RJ45 jack.



5.3. Fibre Patch cords

Fibre outlet patch cords shall be from BELDEN/CDT or Brand-Rex and match the fibre type installed i.e. 62.5/125µm, 50/125µm Multimode or 9/125µm Single mode.

Multi-mode patch cords shall have a LSZH orange sheath and Single mode patch cords shall have a LSZH yellow sheath.

The lengths and connector types will be defined project by project, but where this information is not available the standard shall be:

OM2, 3m, SC-SC orange sheath.

OM3.3m, LC-LC Mint green sheath

OS1, 3m duplex SC-SC yellow sheath

5.4. Outlet Adapters.

Outlet adapters for voice services shall be PABX Master fly lead.

Quantities will be project specific but generally will be one voice adapter per Copper Cable feed pair, to provide maximum flexibility.

6. Backbone Distribution Systems.

Backbone distribution systems are defined as a system, being part of the campus network, that provides connection facilities between equipment/telecommunications rooms and/or building entrance facilities. They may be internal or external.

Components of a backbone will typically include;

Pathways.

Equipment and telecommunication rooms.

Entrance facilities.

Cables and connecting hardware.

Miscellaneous support facilities.

For the purposes of this definition:

A fibre optic backbone includes all fibre panels and transition points.

A voice backbone includes all transition points and voice patch panels.

6.1. Physical Topology.

Physical topology will generally be a star for most LAN applications but other services may require other topologies.

6.2. Allowed Lengths.

Maximum backbone lengths for different cable types are as follows.

UTP Cable (Data) 90m

UTP cable (Voice) 800m

Multimode fibre 2000m

Single mode fibre 3000m

The above may be influenced by applications and in some instances may be considerably shorter.

6.3. Cable Types.

6.3.1 BT CW1600 Internal Voice Cable.

It is noted that although CW1600 is not an allowed cable type in BS EN 50173 or other applicable standards it's use is widespread throughout the campus and will continue to be deployed. CW1600 shall only be deployed internally. Manufacturers are not specified but all cables shall conform to the following specifications.

Operating Temperature	0-70 0C
Conductor	0.5mm tinned annealed copper
Sheath Type	LSZH sheath and core insulation White colour Marked 'LIMITED FIRE HAZARD CABLE FOR TELECOMMUNICATIONS'
Construction	Two insulators twisted together to form pairs or units Number of pairs as required Polyester/aluminium foil screen Fire barrier tape (on more than 10 pair cable)
Operating Temperature °C	0°C to 70°C
Min Insulation Resistance	50 MΩ/km @ 20°C
Min/Max Conductor Resistance	12.4Ω/km / 97.8 Ω/km @ 20°C
Max Unbalanced Capacitance	500pF/500m
Max Conductor Diameter	0.5mm

Cables of 10 pairs and greater shall have an integral 1.38mm diameter earth wire with cream insulation.

All CW1600 cables shall have approximately 50% spare capacity when installed.

Where more than 100 pairs are required then multiple of the relevant sized cable shall be used i.e. not 200 or greater pair cable.

For information purposes;

3 pair	35kg/km	6.0mm OD
4 pair	39kg/km	6.4mm OD
6 pair	53kg/km	6.8mm OD
10 pair plus earth	102kg/km	8.6mm OD
20 pair plus earth	161kg/km	12.0mm OD
40 pair plus earth	295kg/km	15.0mm OD
50 pair plus earth	364kg/km	20.0mm OD
100 pair plus earth	692kg/km	26.0mm OD

6.3.2. BT CW1128 External Voice Cable for Burial in Ducts.

Although it is noted that CW1128 is not an allowed cable type in BS EN 50173 or other applicable standards its use is widespread throughout the campus and will continue to be deployed.

CW 1128 is not suitable for internal use and shall be transitioned to CW1600 as soon as is practicable but in any case within 3m of the building entry.

This transition shall be using box connections, appropriately sized.

CW1128 shall not be terminated directly onto any voice patch panels.

CW1128 shall be used where any section of the voice backbone is to be routed outside the building in conduits or other pathways.

Manufacturers are not specified but all cables shall conform to the following specifications.

Operating Temperature	Max 40 0C
Conductor	0.5mm plain annealed copper
Sheath Type	Cellular PVC Sheath
Construction	Two insulators twisted together to form pairs or units Petroleum jelly water blocking compound filled Number of pairs as required
Operating Temperature °C	-15°C to 80°C
Min Insulation Resistance	1500 MΩ/km @ 20°C
Max Conductor Resistance	90 Ω/km @ 20°C
Average Mutual Capacitance	56nF/km
Max Conductor Diameter	0.5mm

All CW1128 cables shall have approximately 50% spare capacity when installed.

Where more than 100 pairs are required then multiple of the relevant sized cable shall be used i.e. not 200 or greater pair cable.

For information purposes:

3 pair	39g/km	6.0mm OD
4 pair	43kg/km	7.0mm OD
5 pair	55kg/km	8.0mm OD
10 pair	80kg/km	9.5mm OD
20 pair	140kg/km	12.0mm OD
30 pair	195kg/km	14.5mm OD
50 pair	300kg/km	16.5mm OD
100 pair	570kg/km	22.0mm OD

6.3.3. Multi-Mode Fibre.

Multi-mode backbone fibre optic cables shall conform to the following specifications and from the following manufacturer portfolios. Fibre counts shall reflect the overall design requirements, be compatible with any specified or existing mounting hardware and have the correct fibre count modularity to avoid wasting fibre cores due to connection/termination hardware issues.

Fibre Specification Guide
Loose tube

Diameter μm		850 nm		1 300 nm		Gigabit Ethernet Length [m]	
		dB/km	Mhz.km	dB/km	Mhz.km	850 nm	1 300 nm
Multimode 62.5/125	OM1 Premium	3.25	200	1.0	600		
Multimode 50/125	OM2 Standard	3.0	500	1.0	800		
Multimode 50/125	OM2 Premium	3.0	600	1.0	1 200		
Multimode 50/125	OM2 Gigabit	3.0	500	1.0	500	550	550
Multimode 50/125	OM3 10 Gigabit	3.0	1 500	1.0	500	300	

6.3.4. Campus Backbone- multi-mode

BELDEN/CDT – 50/125 μm OM 2. Part number N921160.

This is a dry loose tube construction cable containing 16 fibres with dual FRP strength members, water swell able yarns and glass yarn reinforcement. The core size and count of the fibre will generally be specified in a detailed design statement but in the absence of this information 16 cores shall be installed.

Note: Part number N921162 may be used if part of the route of the cable will be external and no sub ducts are available.

6.3.5. Building Backbone-multi-mode

All multi-mode indoor distribution fibre optic cables shall have a LSZH sheath construction meeting IEC 60332-3-24c (flammability), having an IEC 61034 (Smoke Generation) rating of 0 and an IEC 60754-1 (halogen content) of zero.

Belden/CDT LSZH - 50/125 μm OM 3 or 62.5/125 μm OM 1.

This is a dry loose tube construction cable containing between 4 and 24 fibres with 2 embedded FRP strength members and a LSZH sheath.

The core size and count of the fibre will generally be specified in a detailed design statement but in the absence of this information 24 Cores will be used.

6.3.6. Single Mode Fibre.

Single mode backbone fibre optic cables shall conform to the following specifications and from the following manufacturer portfolios. Fibre counts shall reflect the overall design requirements, be compatible with any specified or existing mounting hardware and have the correct fibre count modularity to avoid wasting fibre cores due to connection/termination hardware issues.

Diameter µm		1 310 nm		1 550 nm	
		dB/km	ps/nm.km	dB/km	ps/nm.km
Single mode 9/125	OS 1	0.4	3.5	0.3	18

6.3.7. Campus Backbone-single mode

BELDEN/CDT – Single mode. 9/125µm OS 1, Part number N924160

This is a dry loose tube construction cable containing 16 fibres with dual FRP strength members, water swell able yarns and glass yarn reinforcement.

The count of the fibre will generally be specified in a detailed design statement but in the absence of this information, 16 cores shall be used.

Note: Part number N921162 may be used if part of the route of the cable will be External and no sub ducts are available.

6.3.8. Building Backbone-single mode

All Single mode indoor distribution fibre optic cables shall have a LSZH sheath construction meeting IEC 60332-3-24c (flammability), having an IEC 61034 (Smoke Generation) rating of 0 and an IEC 60754-1 (halogen content) of zero.

BELDEN/CDT – Single mode. 9/125µm OS 1.

This is a dry loose tube construction cable containing 16 fibres with 2 embedded FRP strength members and a LSZH sheath.

The fibre count will generally be specified in a detailed design statement but in the absence of this information, 16 cores shall be the norm.

6.4. Heavy Cable Installation.

Backbone cables, both voice and fibre can be categorized as heavy cables and special consideration must be made with regard to installation practice. The techniques and specifications in this section can be applied to both building and campus backbone cable.

6.4.1. Bend Radii and Tensions.

Building backbone fibre optic cables shall have a maximum bend radius of 6 times the cable outside diameter when installed and 8 times the cable outside diameter when being installed. These bend radii shall be strictly adhered to unless the cable type is 2-4 core indoor fibre optic when 25mm when installed and 50mm when being installed. Campus backbone fibre optic cables shall have a maximum bend radius of 10 times the cable outside diameter when unloaded and 20 times when under the maximum pulling tension for that cable. Multi core voice backbone cables shall have a minimum of 8 times the cables outside diameter when installed.

The manufacturers pulling tensions shall not be exceeded. No residual tension shall remain on the cable after installation except that due to the cables weight in a vertical rise.

All backbone cables shall be supported via the use of cable or cinch ties in vertical rises, these being installed at appropriate distances.

6.4.2. Installation Guidelines.

Any personnel involved with heavy cable installation shall be suitably trained and familiar with the equipment being used. The maximum distance between joint boxes on the campus is generally no greater than 80m.

Any draw ropes shall be removed after each installation.

The use of duct line blowers or compressors is essential where cables exist in the duct to be roped. Rods are not to be used where an unprotected cable exists in a duct. This method shall be used to blow in draw ropes or wires.

'Cobra' type duct rods can be used for all heavy cable installations where the duct is empty.

The duct rod will be used to pull in a suitable draw rope using an appropriate break load fitting that will separate at 10% of their rated load with Roller guides.

Whichever method is used to install a draw rope, the rope shall be secured to an appropriately sized cable-pulling grip using a D type shackle and swivels. Multiple cables may be pulled with multi cable pulling grips. The cable(s) to be pulled shall then be secured to the pulling grip; tape may also be used to further enhance adhesion.

Cables shall then be pulled through the duct or sub duct either by hand or using appropriate winches and other pulling machinery. The rope shall be pulled in a smooth continuous motion.

The use of winches that monitor the cable tension is the preferred method of pulling multi core backbone fibre optic cables.

Manufacturers guidelines for any equipment or machinery used for installing backbone cables shall be closely followed.

No cable shall be installed in any facilities other than those intended for that use. Gas, drain and water pipes shall not be used for telecommunications ducting under any circumstances.

Cable drums shall be secured on rollers or cable jacks of a suitable carrying capacity.

Cable shall be unspooled from the bottom of the drum into the joint box or manhole.

Sheaves, cable guides, rollers, bell mouths and other means shall be used to maintain the correct bend radius when pulling cable to protect the cable from the sharp edges of manholes, duct mouths etc. and to reduce friction on ducts and sub ducts.

After the pull has been completed, cut and discard 300mm of cable from the end previously being secured to the cable grip.

In addition to general health and safety rules, installers shall observe the following specific safety guidelines:

Use gloves when handling cabling ropes.

Do not interfere with draw ropes or cable whilst they are under tension.

Work sites shall be adequately guarded to protect both installation staff and the general public according to the principles laid down in the NRSWA 1991 and the codes of practice approved under the act.

Ensure that drums on cable jacks are stable before commencing a pull.

When using cable winches if the distance between pulling and feeding ends is not within hailing distance radio communication systems shall be provided.

Only one man, the winch operator is to control any cable winches.

When using winches a second person shall be present to enable the winch operator to concentrate solely on winching operations and to ensure that the rope does not accumulate around the operator's feet.

Release the load on a cable winch before attempting to free any jammed ropes.

When pulling, no person shall be within 1m of the manhole or joint chamber. This rule also applies if the cable or any securing hardware is under tension inside the manhole or joint chamber.

Emergency stop controls on a winch shall be tested prior to the commencement of pulling operations.

Extra care shall be taken to ensure that ropes are not wrapped around any part of the body when pulling operations are in progress.

6.5. Building Entry Points

6.5.1. Re-termination loops.

Approximately 5m of cable shall be formed into a re-termination loop inside the last joint box before the building entry facility.

The cable shall be coiled and secured using formers and mounted on a suitable wall or containment system. Bend radii limitations for all cable types shall be observed.

6.5.2. Securing cable.

Backbone cables shall be securely anchored to the building fabric upon entry, using suitable permanent fixings

6.5.3. Sealing.

All building entry points shall have the relevant ducts sealed using either a mechanical seal (see the Estates Civil's framework document pages 122/123) or Panduit 5 LB Duct seal or a similar product.

6.5.4. Cable Type Transition Distances.

All exterior backbone cables shall be transitioned to the corresponding indoor cable type using the appropriate jointing technology and equipment as soon as is practicable and in any case within 3m of the building entry point i.e. where the exterior cables enter the building.

6.6. Building Pathways.

The logical design of building pathways will generally take the form of a star topology with both fibre and copper cables being utilized.

6.6.1. Riser Conduit Sleeves /Slots.

Standard 100mm diameter plastic conduit shall be used to provide a pathway between floors.

In new build situations the conduits shall be cast into the floor slab but in existing buildings diamond core drilling shall be used. Before commencement of any core drilling activities permission and advice from the U.O.W. Infrastructure Team Leader shall be sought.

The quantity of conduit sleeves shall be determined by the building floor area but will generally be two to four in number.

6.6.2. Riser Cupboards.

Most building on campus have suitable riser cupboards containing the conduit sleeves or slots. These shall be utilized for all building backbone cabling.

6.6.3. Securing Cable.

All intra-building cables shall be secured to the building fabric and/or suitable containment systems such as cable tray upon and entry to and exit from riser conduit sleeves or slots.

6.7. Voice Backbone Termination.

Sufficient re-termination slack shall be looped into a box connection to enable the re-positioning of that strip to any other position within the box connection.

6.7.1. Box Connections.

Box Connections or frames and 237a IDC type disconnection strips shall be used.

All CW1128 cable shall be terminated on Green colour strips.

All CW1600 cable shall be terminated on Blue colour strips

All equipment is to be from the Krone portfolio.

Box connections shall be of a suitable size & type (301/501) to allow for an extra 50% spare capacity when newly installed.

Box connections (either 301 or 501) shall be secured to the fabric of the building using suitably sized permanent fixings.

Outriggers 25A are to be used when installing cables into any 237 Strips on this Site.

CW1257 (yellow/blue) is to be used for jumpering.

Designation strips 51a shall be fitted to each strip for labelling purposes.

Metal box connections may be specified as part of the detailed design requirement. These shall be from the Krone portfolio, e.g. Box Conn 50.

6.7.2. Voice Frames.

Where frames are specified they shall be from the Krone portfolio; Single Vertical Frame 111B, Distribution Frame 108A from the V series

Frames shall be of suitable capacity to allow for an extra 50% spare capacity when newly installed.

Frames shall be secured to the fabric of the building using suitably sized permanent fixings.

In some instances there may be existing frames that the new installation is adding to. In this case, frames from the same manufacturer, as the existing equipment shall be used. After installing a voice frame the retained company shall supply the following Items to be retained with the frame:

One roll of CW1257 jumper wire

One Outrigger 25a (Krone 6417/1/850/00)

One Test Module (Krone 6426/1/022/02)

6.7.3. Patch Panels.

CW1308 & CW1600 voice backbone cable shall be terminated onto either 25 or 50 way voice patch panels, the manufacturer of these panels is usually not specified but should remain the same for each installation. All outlets shall be terminated for 4 wires working with colour schemes are indicated below.

The required Pin outs shall be as follows;

- Pair 1 Pin 4 Blue/White
 Pin 5 White/Blue
- Pair 2 Pin 1 White/Orange
 Pin 2 Orange/White

6.7.4. Earthing, Bonding and lightning Protection.

Refer to the Earthing and bonding section of this document for guidelines covering Earthing, bonding and lightning protection of voice backbones and associated hardware.

6.8. Fibre backbone Termination.

6.8.1. Transition Points.

External fibre backbone cables, for example the Pirelli hybrid fibre, shall be transitioned to a suitable indoor type cable upon entry into the building, or within 3m, after the re-termination loop.

Each core, either multi-mode or single mode shall be fusion spliced.

At least 2m of unsheathed fibre optic cable shall be spooled inside the termination unit using the integral management loops.

The splice enclosure shall be the 3M Quante BPE/O; this shall be securely mounted to the wall using suitable permanent fixings and the supplied wall mounting bracket kit

There are three versions of the BPE/O (I, II and III) and they have a number of options with regards to splice tray capacity. The selection of the type shall depend on the size of the fibres being terminated but in any event the selection shall allow for an over capacity of at least 50%.

The enclosure shall be earthed in accordance with the specifications elsewhere in this document.

From there the indoor cable shall be routed to the relevant rack or wall mounted termination enclosures. The cable will be supported for its entire length using suitable pathways systems such as ladder or tray work.

Single and multi-mode fibres **shall not** be spliced on the same cassette.

Colour coded identification markers shall be used to assist identification.

6.8.2. Rack Mounted Termination Enclosures.

6.8.2.1. Fibre Counts, 16 or less.

Single and multi-mode fibre shall not be mixed onto the same patch panel.

Connector types shall not be mixed on the same patch panel.

The indoor rack mounted termination enclosure where there are 16 fibres or less in a single installation shall be the BELDEN/CDT metal fibre patch panel.

Part number for SC loaded patch panel 8 port duplex Multimode is NN00026

Part number for SC loaded patch panel 8 port duplex Single mode is NN00026

The panel shall be supplied with 8 duplex SC ports regardless of the number of fibres terminated.

Cables shall be secured with the correctly sized strain relief gland and nut.

Where the cable forms part of a campus backbone link all cores (single or multi-mode) shall be terminated using fusion splicing and pigtails from the same manufacturer as the fibre.

Where the cable forms part of a building backbone link all cores (single or multi-mode) can be terminated using direct termination or fusion splicing methods.

All unused connectors shall be fitted with dust caps.

Sufficient cable slack shall be left behind the panel to allow it to be fully extended.

Where loose tube construction cables are being terminated onto this patch panel a suitable fibre breakout device or manifold shall be used to protect the bare fibre strands.

6.8.2.2. Fibre Counts, 25 or more.

In fibre concentration points or in fibre to the desk applications where the fibre count is likely to be greater than 24 a NORDX/CDT Fibre Express shelf (coloured black) shall be installed with enough termination modules for the fibre being terminated.

Unless otherwise specified SC shall be the standard connector type.

Each termination module can house 8 duplex SC modules.

Depending on the application fibres can either be fusion spliced or directly terminated as per the guidelines presented in elsewhere in this document.

Termination modules can be supplied with ST, SC, LC or FC type connectors, either pre terminated or installer terminated. Unless specified by exception in the design statement the standard connector type shall be SC duplex.

Where loose tube cables are to be terminated onto the Fibre Express Manager then the BELDEN/CDT/CDT Fibre Express Flex Kit shall be used to correctly and securely present the individual fibre strands.

6.8.3. Connector colour Coding.

Single mode connectors shall be blue and multimode connectors shall be beige.

7. Earthing, Bonding & Surge Protection.

7.1 Definitions.

7.1.1. Earthing.

Earthing (sometimes referred to as grounding) is defined as a conducting connection between an electrical circuit or equipment and the earth, or some conducting body that serves in place of the earth.

7.1.2. Bonding.

Bonding is defined as the permanent jointing of metallic components to form an electrically conductive low impedance path.

7.2. Authority to Proceed.

Before installing any Earthing or bonding systems the retained company shall seek authorization from the University of Warwick Electrical Engineer.

All installations shall comply with the IEEE 17th Edition Regulations.

7.3. Building Entries.

Each building entry shall be provided with a clean earth bus bar system taken from either the customer main earth terminal or a separate clean earth. The connection cable shall be 16mm cross sectional area (CSA).

This is defined as the Telecommunications Main Grounding bus bar or TMGB

The purpose of the TMGB is to serve as an extension to the building main Earthing electrode and act as a central connection point for telecommunications bonding backbones and connected equipment.

The bus bar shall be mounted on suitably insulated spacers in an easily accessible space, be pre drilled and labelled 'Telecommunications Main Grounding Bus bar'.

Building entries may also serve as TR/ER's

All transition points (either fibre where applicable or copper) shall be connected to this bus bar using 10mm CSA earth cable.

7.4 Telecommunication/Equipment Rooms.

Each TR/ER shall be provided with a clean earth bus bar system taken from the Telecommunication Main Grounding bus bar (TMGB).

The connecting cable shall be 16mm cross sectional area (CSA) and this is defined as the Telecommunication Bonding Backbone (TBB)

The bus bar shall be mounted on suitably insulated spacers in an easily accessible space, be pre drilled and labelled 'Telecommunication Grounding bus bar'.

All telecommunications equipment systems shall be bonded to this bus bar.

Each cabinet or rack shall be bonded to this bus bar using earth cable of 10mm CSA. With Chatsworth frames the rack grounding kit shall be used. Enclosures shall not be cross-bonded; each enclosure shall have a separate Earthing cable connected to the main Telecommunication Grounding bus bar

Each patch panel (where applicable) shall be secured to these rack/cabinet Earthing systems using 6mm CSA earth cable

7.5. Pathway Systems.

All metallic pathway systems shall be bonded to the Main Building Earth with 10mm CSA earth cable.

Where breaks exist in the pathway, these shall be bridged with 10mm CSA earth cable and appropriate connectors or where manufacturers have specific fittings available for this purpose.

7.6. Installation of Earthing/Grounding Conductors.

Earthing/grounding conductors shall be installed with a minimum bend radius of 8x the cable diameter.

Earthing/grounding conductors may be installed in the same pathway systems as horizontal or backbone cable.

7.7. Bonding Techniques.

Bonding is to be durable, strong and of low impedance to assure electrical continuity.

Earth cable fixing bolts must maintain a bonding force of 85-110Kg/cm² (1200-1500 Psi).

Compression fittings shall be cleaned and installed with conductive grease.

Where painted surfaces exist on areas to be bonded these shall be removed prior to fixing.

Conductors shall be kept as straight as possible and shall not be spliced unless compression fittings are used.

7.8. Lightning Protection Systems.

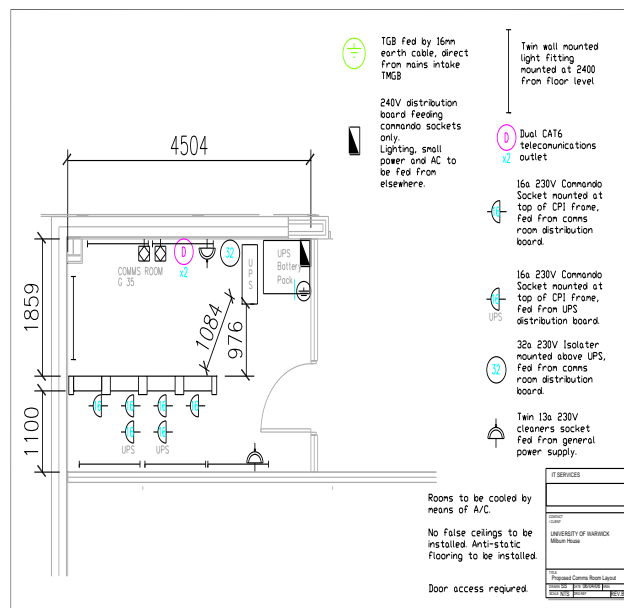
All external copper voice cables shall have lightning protection systems at both ends of the link and for every pair.

Fuse ESP KT1 or ESP K10T1 shall be used.

The Earthing rail supplied with these units shall also be fitted as per the manufacturer's instructions and connected to the TMGB with 10mm CSA earth cable

8. Telecommunication & Equipment Rooms.

10.1. Typical TR/ER Layout.



8.2. Space Allocation.

Space allocation for telecommunication rooms in new buildings will generally follow the guidelines in the various planning guidelines found in CENELEC and ISO standards however in older buildings where modern structured cabling systems were not installed as part of the build the space allocation for telecommunication/equipment rooms may be limited.

As a guide each TR should be a minimum 3mtr x 2.5mtr for every 100 work areas served. Note, in older buildings not suited to structured cabling, a TR may serve more than one floor, in this case, the room size will need to increase to cater for the additional cabling. In all new builds, each floor will have a minimum of one TR per floor.

The height for the TR shall be no less than 2.4mtrs.

Cooling should be designed to run 24/7/365, maintain a positive pressure with a minimum of one air change per hour and keep the room at a temperature between 18 and 24 degrees centigrade with a humidity range of between 30 and 55%. Typical heat loadings will be between 7 and 10kw for an average TR. Please check regarding specific requirements for individual TRs.

8.3. Pathways within the TR/ER.

Pathways within any TR or ER shall be designed to provide easy access to the cables. Given that all horizontal cables will emanate from this location consideration shall also be given to capacity, neatness, minimization of cable stress and ensuring that cables have sufficient spare length to facilitate potential future re organization or change.

The pathways systems within each room will generally be detailed in the design statement but in the absence of such information the following guidelines shall be observed.

Pathway systems within a TR/ER shall be sized to have at least 50% spare capacity.

8.3.1. Raised Floors and Suspended Ceilings.

In general if the TO's are contained in raised floor boxes and cables contained in the raised floor void the TR will also have a raised floor and in this instance cables shall be routed onto frames, cabinets and cross connects etc. from the floor up.

If the TO's are contained in vertical ceiling drops from suspended ceilings or other containment systems then the cables shall be routed at high level down towards the interconnect or cross connect facilities.

Suitable containment systems shall be installed to protect and provide cable management when raised floors and suspended ceilings are present, the preferred type being basket tray for both horizontal and vertical applications.

Care shall be taken when removing floor tiles with specific attention being paid to accident prevention. TR's and ER's WILL NOT have a suspended ceiling. All services entering at high level will be accessible.

8.3.2. Backbone Cables Entering from High or Low Level.

Where backbone cables enter the room from high or low level such as entrance facilities or in a riser cupboard type facilities the cables shall be protected and supported with suitable containment systems. This will generally be basket tray or cable ladder with basket tray being the preferred method.

8.3.3. Room Perimeter Containment.

The preferred method of containment will be high-level 300mm wide basket tray routed around the perimeter of the room with spurs routing to any installed cabinets or open frames using the appropriate connection hardware. The tray system shall be secured to the building fabric in line with specifications elsewhere in this document.

Backbone cables either at high or low level shall also be linked into this room containment system, usually after any re-termination loops have been installed.

8.4. EMI.

No sources of high EMI emitting equipment shall be installed into either TR's or ER's. This includes photocopiers, door openers, industrial equipment etc.

8.5. Floor Standing Frames.

Where open frame type racks are specified the type and make required for the project shall be confirmed by a member of the I.T.Services Infrastructure team.

Each floor standing rack and all its accessories shall be coloured black. The racks shall be secured to the fabric of the building using appropriately sized permanent fixings.

8.5.1. Cable Management for Open Frames.

Each Frame shall be fitted with two 6" double vertical cable managements.

APW 1u management panels shall be used at a ratio of 1 for every 2 Cat6 patch panels, with 6 extra sets per frame allowed for cable management to the active electronic components. Where frames are bade together a transition tray shall be fitted to the bottom and top of the frame. High-level basket tray can be secured to the top of frames using suitable fixings such as J bolts. Cables should flow from the horizontal basket tray to the vertical cabling sections using curved transition plates.

8.5.2. Power.

Each Rack shall be fitted with a 10-way vertical rack mount filtered power distribution unit fitted with a 16amp commando socket and standoff brackets.

8.5.3. Earthing.

Each individual frame shall be fitted a frame grounding kit and earthed to the main earth system as detailed elsewhere in this document.

8.5.4. Miscellaneous.

If the TR has a raised floor the frame shall be fixed to the sub floor using appropriately sized permanent fixings and the raised floor dust cover fitted. Where shelves are specified they shall be from the same range as the frame manufacturer.

Each new frame shall be supplied with 50 combination pan head, pilot point mounting screws, coloured black.

8.6. Communications Cabinets.

Generally, all new CRs will be fitted with open frames as detailed above. However in certain installations, residential buildings for instance, there may be a need to install floor standing cabinets to house horizontal and backbone cabling, active equipment and environmental monitoring devices. Where a cabinet is detailed to be installed, its specification will usually be detailed in the scope of works, but will generally have the following components:

- Heavy duty castors.
- 19" front mounting verts.
- Vented top cover.
- Fan Tray
- 6 way PDU fitted with 13amp IEC plug.
- Locking front and rear doors.
- Locking side panels.

8.6.1. Power Supply for Communications Cabinets.

A 16 amp commando socket should be installed for each communications cabinet installed, unless otherwise specified. The socket should be located either to the rear or side of the cabinet position.

The supply must be fed from its own dedicated radial circuit.

8.6.2. Earthing the cabinet.

Where a communications cabinet is not installed in a dedicated CR, where Earthing arrangements are already detailed. A separate 16mm CSA earth will be installed from the main building incoming location, to either a TMGB or TGB located either behind or to the side of the communications cabinet.

8.7. Telecommunication Room Patch Cords.

8.7.1. Voice.

Green RJ45-RJ45 Category 6 patch cords with moulded boots are used for voice patching. Retained companies shall provide one patch cord for each voice pair of a suitable length for patching within the frame or cabinet that the panel is installed into.

Red RJ45-RJ45 Category 6 patch cords with moulded boots are used for VOIP patching. Retained companies shall provide one patch cord for each voice pair of a suitable length for patching within the frame or cabinet that the panel is installed into.

8.7.2. Category 6 Patch Cords.

Patch cords used for patching within TR's shall be Grey and from the BELDEN/CDT PS 6 range, RJ-45 to RJ-45.
Or BRAND-REX RJ-45 to RJ-45

One patch cord shall be supplied for each RJ-45 panel outlet installed of 2mtr in length unless otherwise specified.

8.7.3. Fibre Optic.

Fibre optic patch cords will normally be defined in the detailed design statement. However, in the absence of this each duplex SC connector presented on a patch panel shall be provided with a 3m SC-SC (duplex) patch cord coloured orange for multi-mode ports and yellow for single mode ports.

Fibre patch cords shall be either from BELDEN/CDT or BRAND-REX.

9. Administration.

Administration includes labelling, software, plans and other resources to enable the efficient management of the installed telecommunications installation.

This section also defines the project handover documentation and information required.

9.1. Labelling

9.2. Backbone Cables Contained in Outside Plant.

Backbone cables contained in outside plant shall have cable tie marker(s) such as the Panduit PL3M2S or equivalent affixed upon entry to and exit from any duct or sub duct and shall be marked with the following information (in indelible pen).

- Type i.e. fibre or copper
- Approx. Length in meters
- Building. A Code e.g. C-SB-E-3/0A
- Building. B Code e.g. C-SS-A-7/2A
- Date e.g. 10/10/01

More than one cable tie marker may be used if required.



In addition, if the cable type is fibre then a laser-warning label shall also be fixed adjacent to the above label. These labels are available from the UoW Infrastructure Team Leader.

9.2.1. Building Entry.

Backbone cables shall have cable tie marker(s) such as the Panduit PL3M2S or equivalent affixed upon entry into the building, before the re-termination loop and shall be marked with the following information (in indelible pen).

- Type i.e. fibre or copper
- Approx. Length in meters
- Building code fed from e.g. C-SB-H-3/0A
- Date e.g. 10/10/01

In addition, if the cable type is fibre then a laser-warning label shall also be fixed adjacent to the above label. These labels are available from the UoW Infrastructure Team Leader.

9.2.2. Fibre Transition Enclosures.

Fibre transitioned in Quante fibre transition enclosures shall be labelled with heat shrink labels printed labels either side of the splice with the following information.

- Fibre type i.e.62.5µm
- Manufacturer i.e.Nexans
- Building code fed from e.g. C-SB-H-3/0A
- Date of splice i.e.12.03.01

9.2.3. Voice cable Box Connections.

Within the box connections each 237a strip is to be labelled with designation Strips 51a using electronically printed labels or card strips. The label shall denote the circuit ID.

Box connections shall be labelled via the use of a self-adhesive electronically printed label denoting the DP ID and cable source/destination. The label is to be located on the lid. The format shall be black text on white background in a non-serif type font.

9.2.4. Horizontal Cable System Labelling.

The labelling of horizontal cabling systems can be very complex and unwieldy. Because of the discrete nature of each buildings cable infrastructure, there is a need to provide each port with both a unique building and comms identifier. These are available upon request.

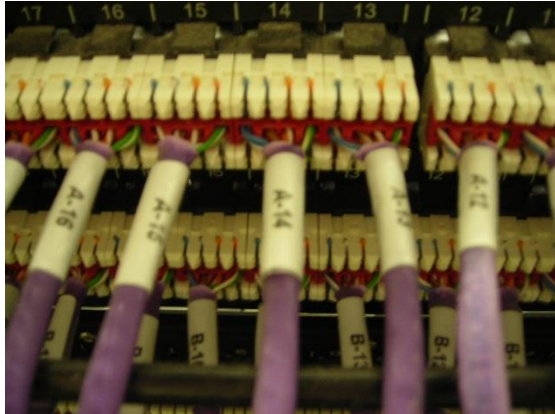
Each TR/ER may have more than 26 RJ45 patch panels, so it is possible that multiple first digits of the panel indicator may be assigned to that particular room. i.e. Panel 1 will be A-01 to A-24, panel 2 will be B-01 to B-24 and so on until panel 26 which will be Z-01 to Z-24. Panel 27 will be AA-01 to AA-24, panel 28 will be AB-01 to AB-24

9.2.4.1. Colour Coding.

- Orange: Demarcation point (e.g., central office {telephone exchange} connections).
- Green: Network connections (e.g., network and auxiliary equipment).
- Purple: Common equipment (e.g., connections to PBX, mainframe computer, LAN, multiplexer).
- White: First-level backbone (e.g., termination of building backbone cable Connecting MC [CD] to ICs [BDs]).
- Grey: Second-level backbone (e.g., termination of building backbone cable Connecting ICs [BDs] to HCs [FDs]).
- Blue: Horizontal cable (e.g., horizontal connections to telecommunications Outlet/connectors; formerly referred to as "station cable").
- Brown: Inter building backbone (campus cable terminations). NOTE: Brown takes precedence over white or grey for inter building runs.
- Yellow: Miscellaneous (e.g., auxiliary, alarms, security).
- Red: Reserved for future use (also, key telephone systems).

9.2.4.2. Copper Cable.

Cables shall be labelled with Brady or equivalent self-adhesive printed wrap around labels 200mm from a patch panel termination point and within 100mm of a work area termination. The labelling scheme shall match the patch panel and face plate port ID.



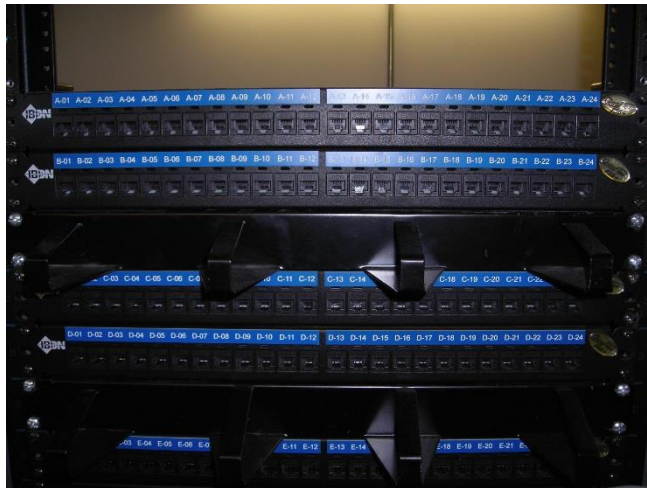
9.2.4.3. Fibre Cable.

Each fibre optic horizontal cable shall be labelled with an engraved label using the correct colour and fixed with tie wraps as shown below, 200mm from the patch panel. The labelling scheme shall match the patch panel.



9.2.4.4. Cat 6 Patch Panels.

Each patch panel port shall be labelled with a unique engraved adhesive label. The labelling scheme will normally be defined in the detailed design statement and will follow a simple alphanumeric port indicator i.e. A-01 to A-24, B-01 to B-24 etc. The format shall be white text on blue background.



9.2.4.5. Fibre panels.

Each duplex fibre termination port shall be labelled with a unique engraved adhesive label. The labelling scheme will normally be defined in the detailed design statement but in the absence of this information each duplex port shall be labelled with a two digit numeric port indicator and a two digit alphanumeric panel indicator with the panel indicator coming first in the sequence. The format shall be as detailed in the above colour codes section. In addition, each fibre patch panel or breakout box shall have a self-adhesive laser warning label affixed in a visible position.

9.2.5. Work Area Labelling.

9.2.5.1. Telecommunications Outlet.

Each telecommunication outlet shall be labelled with an appropriately sized, 40mil x 10mil, engraved label reflecting the patch panel numbering scheme. The format shall be white text on blue background.

Labels shall be fixed below the RJ45 port. In addition, a comms room ID label is to be fitted to each telecommunications outlet plate. This will be an appropriately sized engraved label reflecting the comms room code that the outlet is served from. The format shall be black text on white background

In addition, a comms room ID label is to be fitted to each telecommunications outlet plate. This will be an appropriately sized engraved label reflecting the comms room code that the outlet is served from. The format shall be black text on white background.



9.2.5.2. Telecommunications/Equipment Rooms.

9.2.5.3. Wall and Floor Mounted Cabinets.

Each wall or floor mounted cabinet shall have an A6 sized label fixed to the front door, top right, detailing the comms room code ID. The format shall be black text on white background in a non-serif type font.

9.2.5.4. Open Frames.

Open frames shall have a suitably sized engraved label fixed to the top of the frame, detailing which floor the frame serves. The format shall be black text on white background in a non-serif type font.

9.3. Drawings and Diagrams.

9.3.1. Issue.

Drawings and diagrams may be issued to the retained company during the course of an installation as applicable. Drawings may be issued from either the University or a contract principal.

9.3.2. As Installed Drawings.

Each project shall be supplied with the following drawing types;

Logical network schematic to include outlet quantities and cabinet layouts.

CAD drawing in Autodesk AutoCAD 2005 or later format with telecommunication outlets, containment routes, ER/TR locations and Earthing points shown. Each of these categories shall be on a separate named layer.

Both electronic and paper copies shall be supplied. Paper copies shall, where applicable, be printed to a known architectural scale such as 1:100

Cabinet or frame schematics shall be in Visio or AutoCAD formats.

If the installation includes campus backbone cables the retained company shall annotate a supplied campus plan drawing with the routes taken, transition point locations and cable types. The UoW Infrastructure Team Leader shall supply a suitable drawing to be annotated.

In addition to the drawings specified above electronic images of the following shall also be supplied:

- Entrance facilities
- Transition Points
- Risers
- Consolidation Points
- Cabinets/Frames
- Telecommunication rooms
- Outlet

9.4. Software.

9.4.1. Test Results.

Any test results supplied in their native format shall also be supplied with a copy of the test result management software, free of charge.

9.5. Warranties.

The University of Warwick requires a supplier/contractor warranty period of 36 Months for workmanship from the acceptance date. Further to this, The University of Warwick expects to receive a manufacturer's systems / applications warranty of not less than twenty five years.

Quotation submitters shall provide details of warranty coverage under the following circumstances:

Installer ceases trading.

Installer ceases to be accredited.

The installation should be carried out by BELDEN/BRAND-REX / accredited installers.

The installers may be required to show proof of the BELDEN/BRAND-REX Training.

9.6. Project Handover Folder.

The form of the reporting documentation shall be as follows, and in this order.

9.6.1. Title Page.

Containing the text, 'Technical Manual for Telecommunications Cabling at the University of Warwick – INSERT PROJECT NAME HERE'.

Name, address and telephone number of the retained company.

Date of handover.

Photographic image of the buildings front elevation.

9.6.2. Table of Content.

A list of enclosed sections.

9.6.3. System Description.

A brief overview of the project and its elements.

9.6.4. Drawings, Diagrams & Images.

All requested drawings and diagrams as detailed elsewhere in this document or defined in the detailed design statement which will include AutoCAD floor plans, JPEG Images of all Cabs, Riser, Cable Chambers & the outside of the Buildings.

9.6.5. Schematic.

All requested schematic drawings detailing the installed telecommunications cabling system.

9.6.6. Equipment Rooms.

All requested details and drawings detailing all ERs, TRs.

9.6.7. Warranty/Compliance Certificates.

Warranty certificates to comply with the Cabling system installed.

9.6.8. Test Results.

Summaries of all Level III test results and full print outs of any OTDR traces, Power and light source test results and voice continuity test results.

Any electrical work carried out by the retained company or its approved sub-contractors shall be supplied with a 'Minor Electrical Installation Works Certificate (BS 7671:1992).

9.6.9. Method Statements.

Method statements of all works carried out by the contractor.

9.6.10. Health & Safety.

Health and safety policy including risk assessments, of all works carried out by the contractor or sub-Contractors.

9.6.11. Quality Assurance Plan.

Quality Assurance Plan of the contractor.

9.6.12. Maintenance Procedures.

Any maintenance procedures that need to be carried out on the works installed by the contractor in order to keep within the warranty conditions.

9.6.13. Fault Call out Procedure.

A detailed statement defining fault reporting and warranty claim procedures.

9.7. Electronic Handover Information.

As part of the handover folder the retained company shall provide a CD, formatted to allow reading in conventional read only drives, containing all of the chapters within the handover folder.

10. Testing.

10.1. Witness Testing & Third Party Verification.

100% of all the installed links shall be tested. The University of Warwick reserves the right to request a 10% witness test of all installed outlets/links. This is to be at no extra cost to the University. If during this 10% witness test, a failure is found, the University of Warwick reserve the right to a full 100% test of all installed links. This will be at no cost to the University of Warwick.

10.2. Class E Permanent Link.

Testing shall be performed using a Level 3 Field Tester to BSEN 50173/ISO11801 which shall be either a Fluke DTX1800, DSP4300 or equivalent. Every cabling link in the installation shall be tested in accordance with IEC 61935. The installed twisted-pair horizontal links shall be tested from the floor distributor in the telecommunications room to the telecommunication outlet in the work area against the "Permanent Link" performance limits specification as defined in ISO/IEC 11801 2002.

100% of the installed cabling links must be tested and must pass the requirements of the standards mentioned above and as further detailed below. Any failing link must be diagnosed and corrected. The corrective action shall be followed with a new test to prove that the corrected link meets the performance requirements. The final and passing result of the tests for all links shall be provided in the test results documentation in accordance with the test result documentation section of this document.

The test equipment (tester) shall comply with or exceed the accuracy requirements for enhanced level III field testers. The tester shall be within the calibration period recommended by the vendor in order to achieve the vendor-specified measurement accuracy.

The tester interface adapters must be of high quality and the cable shall not show any twisting or kinking resulting from coiling and storing of the tester interface adapters. In order to deliver optimum accuracy the permanent link interface adapter for the tester shall be calibrated to extend the reference plane of the Return Loss measurement to the permanent link interface.

The Pass or Fail condition for the link-under-test is determined by the results of the required individual tests. Any Fail or Fail* result yields a Fail for the link-under-test.

In order to achieve an overall Pass condition, the results for each individual test parameter must Pass or Pass*.

A Pass or Fail result for each parameter is determined by comparing the measured values with the specified test limits for that parameter. The test result of a parameter shall be marked with an asterisk (*) when the result is closer to the test limit than the accuracy of the field tester.

10.2.1. Performance Test Parameters.

The test parameters for Class E are defined in ISO/IEC 11801 Amendment 2 (2002).

The test of each Class E link shall contain all of the following parameters as detailed below. In order to pass the link test all measurements (at each frequency in the range from 1 MHz through 100 MHz) must meet or exceed the limit value determined in the above-mentioned Class E standard.

Each parameter shall be measured from 1 through 350 MHz and all of these measurement points are to be recorded in the test results information.

10.2.1.1 Wire Map.

Wire Map shall report Pass if the wiring of each wire-pair from end to end is determined to be correct. The Wire Map results shall include the continuity of the shield connection if present.

10.2.1.2. Length.

The field tester shall be capable of measuring length of all pairs of a permanent link or channel based on the propagation delay measurement and the average value for NVP. The physical length of the link shall be calculated using the pair with the shortest electrical delay. This length figure shall be reported and shall be used for making the Pass/Fail decision. The Pass/Fail criteria is based on the maximum length allowed for the permanent link configuration (90 meters) or the channel (100 meters).

10.2.1.3. Insertion Loss (Attenuation)

Insertion Loss is a measure of signal loss in the permanent link or channel. The term 'Attenuation' has been used to designate 'insertion losses'. Insertion Loss shall be tested from 1 MHz through 100 MHz in maximum step size of 1 MHz. It is preferred to measure attenuation at the same frequency intervals as NEXT Loss in order to provide a more accurate calculation of the Attenuation-to-Crosstalk Ratio (ACR) parameter. Minimum test results documentation (summary results): Identify the worst wire pair (1 of 4 possible). The test results for the worst wire pair must show the highest attenuation value measured (worst case), the frequency at which this worst-case value occurs, and the test limit value at this frequency.

10.2.1.4. NEXT Loss Pair to Pair.

Pair-to-pair near-end crosstalk loss (abbreviated as NEXT Loss) shall be tested for each wire pair combination from each end of the link (a total of 12 pair combinations). This parameter is to be measured from 1 through 100 MHz. NEXT Loss measures the crosstalk disturbance on a wire pair at the end from which the disturbance signal is transmitted (near-end) on the disturbing pair. The maximum step size for NEXT Loss measurements shall not exceed the maximum step size defined in the standard.

Minimum test results documentation (summary results): Identify the wire pair combination that exhibits the worst case NEXT margin and the wire pair combination that exhibits the worst value of NEXT (worst case). NEXT is to be measured from each end of the link-under-test. These wire pair combinations must be identified for the tests performed from each end. Each reported case shall include the frequency at which it occurs as well as the test limit value at this frequency.

10.2.1.5. PSNEXT Loss.

Power Sum NEXT Loss shall be evaluated and reported for each wire pair from both ends of the link-under-test (a total of 8 results). PSNEXT Loss captures the combined near-end crosstalk effect (statistical) on a wire pair when all other pairs actively transmit signals. Like NEXT this test parameter must be evaluated from 1 through 100 MHz and the step size may not exceed the maximum step size defined in the standards as above.

Minimum test results documentation (summary results): Identify the wire pair that exhibits the worst-case margin and the wire pair that exhibits the worst value for PSNEXT. These wire pairs must be identified for the tests performed from each end. Each reported case shall include the frequency at which it occurs as well as the test limit value at this frequency.

10.2.1.6 ELFEXT Loss Pair to Pair.

Pair-to-pair FEXT Loss shall be measured for each wire-pair combination from both ends of the link-under-test. FEXT Loss measures the unwanted signal coupling (crosstalk disturbance) on a wire pair at the opposite end (far-end) from which the transmitter emits the disturbing signal on the disturbing pair. FEXT is measured to compute ELFEXT Loss that must be evaluated and reported in the test results. ELFEXT measures the relative strength of the far-end crosstalk disturbance relative to the attenuated signal that arrives at the end of the link. This test yields 24 wire-pair combinations. ELFEXT is to be measured from 1 through 100 MHz and the maximum step size for FEXT Loss measurements shall not exceed the maximum step size defined in the standard above.

Minimum test results documentation (summary results): Identify the wire pair combination that exhibits the worst-case margin and the wire pair combination that exhibits the worst value for ELFEXT. These wire pairs must be identified for the tests performed from each end. Each reported case shall include the frequency at which it occurs as well as the test limit value at this frequency.

10.2.1.7. PSELFEXT Loss.

Power Sum ELFEXT is a calculated parameter that combines the effect of the FEXT disturbance from three wire pairs on the fourth one. This test yields 8 wire-pair combinations. Each wire-pair is evaluated from 1 through 100 MHz in frequency increments that do not exceed the maximum step size defined in the standards as shown above.

Minimum test results documentation (summary results): Identify the wire pair that exhibits the worst-case margin and the wire pair that exhibits the worst value for PSELFEXT. These wire pairs must be identified for the tests performed from each end. Each reported case shall include the frequency at which it occurs as well as the test limit value at this frequency.

10.2.1.8. Return Loss.

Return Loss (RL) measures the total energy reflected on each wire pair. Return Loss is to be measured from both ends of the link-under-test for each wire pair. This parameter is also to be measured from 1 through 100 MHz in frequency increments that do not exceed the maximum step size defined in the standard.

Minimum test results documentation (summary results): Identify the wire pair that exhibits the worst-case margin and the wire pair that exhibits the worst value for Return Loss. These wire pairs must be identified for the tests performed from each end. Each reported case shall include the frequency at which it occurs as well as the test limit value at this frequency.

10.2.1.9. ACR (Attenuation to Crosstalk Ratio).

ACR provides an indication of bandwidth for the two wire-pair network applications. ACR is a computed parameter that is analogous to ELFEXT and expresses the signal to noise ratio for a two wire-pair system. This calculation yields 12 combinations – six from each end of the link.

Minimum test results documentation (summary results): Identify the wire pair combination that exhibits the worst-case margin and the wire pair combination that exhibits the worst value for ACR. These wire pair combinations must be identified for the tests performed from each end. Each reported case shall include the frequency at which it occurs as well as the test limit value at this frequency.

10.2.1.10. PSACR.

The Power Sum version of ACR is based on PSNEXT and takes into account the combined NEXT disturbance of all adjacent wire pairs on each individual pair. This calculation yields 8 combinations – one for each wire pair from both ends of the link.

Minimum test results documentation (summary results): Identify the wire pair that exhibits the worst-case margin and the wire pair that exhibits the worst value for PSACR. These wire pairs must be identified for the tests performed from each end. Each reported case shall include the frequency at which it occurs as well as the test limit value at this frequency.

10.2.1.11. Propagation Delay.

Propagation delay is the time required for the signal to travel from one end of the link to the other. This measurement is to be performed for each of the four wire pairs.

Minimum test results documentation (summary results): Identify the wire pair with the worst-case propagation delay. The report shall include the propagation delay value measured as well as the test limit value.

10.2.1.12. Delay Skew.

This parameter shows the difference in propagation delay between the four wire pairs. The pair with the shortest propagation delay is the reference pair with a delay skew value of zero.

Minimum test results documentation (summary results): Identify the wire pair with the worst-case propagation delay (the longest propagation delay). The report shall include the delay skew value measured as well as the test limit value.

10.2.2. Test Result Documentation.

The test result information for each link shall be recorded in the memory of the field test equipment upon completion.

The test result records saved by the test equipment shall be transferred into a Windows based database utility that allows for the maintenance, inspection and archiving of these test records.

The database for the completed job shall be stored and delivered on CD-ROM; this CD-ROM shall include the software tools required to view, inspect, and print any selection of test reports.

A paper copy of the test results shall be provided that lists all the links that have been tested with the following summary information:

The overall Pass/Fail evaluation of the link-under-test including the NEXT Headroom (overall worst case) number

The date and time the test results were saved in the memory of the tester

General Information to be provided in the electronic database with the test results information for each link:

The identification of the customer site as specified by the end-user

The identification of the link in accordance with the naming convention defined in the overall system documentation

The overall Pass/Fail evaluation of the link-under-test

The name of the standard selected to execute the stored test results

The cable type and the value of NVP used for length calculations

The date and time the test results were saved in the memory of the tester

The brand name, model and serial number of the tester

The identification of the tester interface

The revision of the tester software and the revision of the test standards database in the tester

The test results information must contain information on each of the required test parameters that are listed above.

The detailed test results data to be provided in the electronic database for each tested link must contain the following information.

For each of the frequency-dependent test parameters, the value measured at every frequency during the test is stored. In this case, the PC-resident database program must be able to process the stored results to display and print a colour graph of the measured parameters.

10.3. Fibre.

Every fibre optic cabling link in the installation shall be tested in accordance with the field test specifications defined by the CENELEC (Comité Européen de Normalisation Electrotechnique) standard EN 50173 or by the appropriate network application standard(s) whichever is more demanding.

EN 50173 defines the passive cabling network, to include cable, connectors, and splices (if present), between two optical fibre patch panels (connecting hardware). A typical horizontal link segment is from the telecommunications outlet/connector to the horizontal cross-connect. A building backbone cabling subsystem extends from building distributor(s) to the floor distributor(s). The test shall include the representative connector performance at the connecting hardware associated with the mating of patch cords. The test does not, however, include the performance of the connector at the interface with the test equipment.

100% of the installed cabling links must be tested and must pass the requirements of the standards mentioned above and as further detailed later in this document. Any failing link must be documented, diagnosed and corrected. The corrective action shall be followed with a new test to prove that the corrected link meets the performance requirements. The final and passing result of the tests for all links shall be provided in the test results documentation in accordance with the administration section of this document.

The test equipment shall comprise optical power source and meter equipment in accordance with IEC 61280-4-1 (for multimode optical fibres) and IEC 61280-4-2 (for single mode optical fibres). The type of optical source and launch condition shall correspond with one of the categories defined in IEC 61280-4-1 (for multimode optical fibres) and IEC 61280-4-2 (for single mode optical fibres).

The cabling interface adaptors consist of a number of test cords mating in accordance with IEC 61280-4-1 (for multimode optical fibres) and IEC 61280-4-2 (for single mode optical fibres).

The test equipment shall be within the calibration period recommended by the manufacturer in order to achieve the manufacturer-specified measurement accuracy.

The fibre optic launch cables and adapters must be of a high quality and the cables shall not show excessive wear resulting from repetitive coiling and storing of the test equipment interface adapters. No index matching gel shall be used.

10.3.1. Performance Test Parameters.

EN 50173 prescribes the single performance parameter for field-testing of fibre optic links as link attenuation (alternative and equivalent term: insertion loss), when installing components compliant with this standard. The link attenuation shall be calculated in accordance to the specifications within EN 50173. These specifications are representative of the following formulas.

- $\text{Link_Attn} = \text{Cable_Attn} + \text{Connector_Attn} + \text{Splice_Attn}$
- $\text{Cable_Attn (dB)} = \text{Attenuation Coefficient (dB/km)} * \text{Length (km)}$
- The values for the Attenuation Coefficient are listed in the table below:

Type of Optical Fibre	Wavelength (nm)	Attenuation Coefficient (dB/km)
Multimode 62.5/125 μm	850	3.5
	1300	1.5
Multimode 50/125 μm	850	3.5
	1300	1.5
Single-mode	1310	1.0
	1550	1.0

- $\text{Connector_Attn (dB)} = \text{number of connector pairs} * \text{connector loss (dB)}$
- Maximum allowable connector loss = 0.75 dB
- $\text{Splice_Attn (dB)} = \text{number of splices (S)} * \text{splice loss (dB)}$
- Maximum allowable splice loss = 0.3 dB

Link attenuation does not include any active devices or passive devices other than cable, connectors, and splices, i.e. link attenuation does not include such devices as optical bypass switches, couplers, repeaters, or optical amplifiers.

Test equipment that measures the link length and automatically calculates the link loss based on the above formulas is preferred.

The above link test limits attenuation are based on the use of the One Reference Jumper Method specified by Method 1 of IEC 61280-4-1 for multimode and Method 1 of IEC 61280-4-2 for single mode. The user shall follow the procedures established by these standards or test equipment manufacturer recommended modifications.

The horizontal link (multimode): acceptable link attenuation for a multimode horizontal optical fibre cabling system is based on the maximum 90 m distance. The horizontal link should be tested at both wave lengths and in both directions i.e. A-B & B-A in accordance with Method 1 of IEC 61280-4-1, One Reference Jumper. The backbone link (multimode) shall be tested in one direction at both operating wavelengths to account for attenuation deltas associated with wavelength.

Multimode backbone links shall be tested at 850 nm and 1300 nm in accordance with Method 1 of IEC 61280-4-1 or test equipment manufacturer recommended modifications.

Because backbone length and the potential number of splices vary depending upon site conditions, the link attenuation equation shall be used to determine limit (acceptance) values.

Single mode backbone links shall be tested at 1310 nm and 1550 nm in accordance with IEC 61280-4-2, One Reference Jumper or test equipment manufacturer recommended modifications.

All single mode links shall be certified with test tools using laser light sources at 1310 nm and 1550 nm (See Note below).

Links destined to be used with network applications that use laser light sources (under filled launch conditions) shall be tested with test equipment based on laser light sources categorized by a Coupled Power Ratio (CPR) of Category 2, Under filled, per IEC 60825-2.

This rule should be followed for cabling systems to support Gigabit Ethernet. Gigabit Ethernet only specifies laser light sources. Field test equipment based on LED (light emitting diode) light sources is a Category 1 device per IEC 60825-2 and typically yields high attenuation results.

For Gigabit Ethernet compliant certification (IEE 802.3z application), use test equipment, which uses a VCSEL (Vertical cavity surface emitting laser) at 850 nm (compliant with 1000BASE-SX) and an FP laser at 1310 nm (compliant with 1000BASE-LX).

Horizontal cables shall not exceed 90m and backbone cables shall not exceed 2000m, split between 500m for building backbone and 1500m for campus backbone links.

10.3.2. Test Result Documentation.

The test result information for each link shall be recorded in the memory of the field test equipment upon completion.

The test result records saved by the test equipment shall be transferred into a Windows based database utility that allows for the maintenance, inspection and archiving of these test records.

The database for the completed job shall be stored and delivered on CD-ROM; this CD-ROM shall include the software (with "SOR" as the prefixed File format) tools required to view, inspect, and print any selection of test reports.

A paper copy of the test results shall be provided that lists all the links that have been tested with the following summary information.

The overall Pass/Fail evaluation of the link-under-test including the Attenuation worst-case margin (margin is defined as the difference between the measured value and the test limit value).

The date and time the test results were saved in the memory of the test equipment.

General Information to be provided in the electronic database containing the test result information for each link:

The identification of the customer site as specified by the end-user

The overall Pass/Fail evaluation of the link-under-test

The name of the standard selected to execute the stored test results

The cable type and the value of the 'index of refraction' used for length calculations

The date and time the test results were saved in the memory of the test equipment

The brand name, model and serial number of the test equipment

The revision of the test equipment software and the revision of the test standards database in the test equipment

The detailed test results data to be provided in the electronic database for each tested optical fibre must contain the following information

The identification of the link/fibre in accordance with the naming convention defined in the overall system documentation.

The attenuation measured at each wavelength, the test limit calculated for the corresponding wavelength and the margin (difference between the measured attenuation and the test limit value).

The link length shall be reported for each optical fibre for which the test limit was calculated based on the formulas above

10.4. Voice.

- 100% testing shall be performed to identify;
- Any miss wire.
- Earths.
- Short circuit.
- Continuity of the cable pairs.

In addition to the above basic tests the following shall also be provided for newly installed voice backbones:

- Loop resistance
- Insulation resistance
- Length using TDR equipment

University of Warwick

Project Name



Copper Communication Cables Test Sheet

Number	
Type	
Location	
Length	

Installed	
From	
To	
Date	
Weather	

Pair Number	LR (Ω)	IR (MΩ)		
		A-Earth	B-Earth	A-B
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				
21				
22				
23				
24				
25				

Pair Number	LR (Ω)	IR (MΩ)		
		A-Earth	B-Earth	A-B
26				
27				
28				
29				
30				
31				
32				
33				
34				
35				
36				
37				
38				
39				
40				
41				
42				
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44				
45				
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47				
48				
49				
50				

For all voice backbone links the results shall presented in the handover documentation on a voice test sheet as detailed.