

UTP Installation Guide

- Category 5e
- Category 6

UTP cables were developed and designed to be used independent of the system application. Set transmission performance criteria (Categories) have been established for the various grades of UTP cables.

What are these Categories?

Categories are a method of classifying UTP cables and related hardware within specific performance criteria.

Category 5e - Specifies cable and connecting hardware with transmission characteristics up to 100 MHz. It differs from Category 5 by having 3 dB tighter NEXT requirements and additional requirements for PS NEXT, ELFEXT, PS ELFEXT, and RL.

Category 6 - This document specifies cable and connecting hardware with transmission characteristics up to 250 MHz. In addition, Category 6 has tighter insertion loss, NEXT, PS NEXT, ELFEXT and PS ELFEXT over Category 5e.

Cable Handling

Length

The maximum horizontal cable length is 90 meters (295 feet). Ten meters is allowed for cords in the work area, and for patch cords or jumpers in the telecommunications closet.

The maximum backbone cable length is 90 meters (295 feet). This 90 meter length assumes that 5 meters (16 feet) are needed at each end for equipment cables connecting to the backbone.

Pulling Tension

Maximum pulling tension for a 4 pair horizontal cable is 25 lbf. Excessive pulling tensions may occur during installation. Once the damage is done, reversing the effect may not be sufficient enough to correct the problem and cable replacement is recommended. Intermediate cable pulls within the overall cable run may be necessary to avoid exceeding the maximum pulling force.

Minimum Bend Radius

4 pair UTP cables have a 1" Min. Bend Radius.

CAUTION: Exceeding the minimum bend radius can distort the cable geometry and result in degrading of transmission performance.

Repositioning of the cable to the proper bend radii may not correct the fault. Once the damage is done, the best option is replacement of the damaged run.

There are two common places where exceeding the minimum bend may occur:

- *At the workstation wall outlet.* After the cable is terminated, too often the remaining cable is jammed into the wall outlet, or worse, wrapped around itself and shoved into the outlet. A better practice would be to gently work the excess cable length back through the wall outlet into the wall.
- *At the wiring closet, during routing of the cable to the terminal block or patch panel.* Prior cable placement practices may have encouraged making the cable appear as formfitting or tight against the routing structure (cable tray or rack) as possible. A better practice would be to incorporate gently sweeping curves along the cable path avoiding sharp bends or changes in direction. Every effort should be made to ensure the path the cable follows has smooth gradual sweeps at any transition point.

Installation in Temperatures Below Freezing

The minimum installation temperature for plenum cables is 0° C (32° F). If the cable has to be installed when the temperature is below 32° F the following precautions should be taken to ensure that the jacket will not crack:

- Store the cable in a heated area whose temperature is above 50° F for 24 hours before installation.
- Transfer only enough cable to the job site for 4 hours work. The cable will retain enough heat to prevent cracking. Cable

that has not been installed after 4 hours should be returned to a heated area.

- Coil service loops in 10" to 12" loops. A tight coil could cause the cable to crack.
- Normally the cables are terminated after the site is enclosed and heated. Do not attempt to terminate the cables when the temperature is below freezing.

Over Stressing

Eliminate cable stress caused by tension in suspended cable runs and tightly cinched cable bundles

Excessive cable loading or stress can also occur if a cable is incorrectly suspended in a cable run. A recommended cable support spacing is 48" to 60" centers.

Avoid twisting of cable during installation. Excessive twisting may result in distortion of cable geometry, and in severe cases tears in the jacket.

In addition to the above guidelines extracted from TIA/EIA-568, Mohawk strongly recommends the following supplementary installation tips:

- Do not walk or step on high performance cable. Do not run over high performance cable with hand trucks or forklifts. This will exert excessive force on the cable, distorting the geometry and/or crushing the pairs, resulting in electrical shorts.
- Do not use staples, either from a staple gun or mounting in a traditional manner with a hammer. Staples can exert excessive force on the cable and distort the pair geometry.
- D-Rings, nail on clamps or Velcro® straps offer acceptable cable management techniques without compressing the cable.
- Do not run cable near sources of heat, as this may negatively impact cable attenuation.
- Maintain a 6" minimum spacing between cables and sources of EMI, such as fluorescent lights or unshielded power lines.

Termination

The installer must be acquainted with the Connector Manufacturer's installation instructions. The correct tools, wire layout and untwist length are critical, especially in Category 6 installations. Modular jacks usually have the Pair color code marked on the jack. The color code can be either T568A or T568B wiring methods. Maintain the same pin to pair combination throughout the installation. Changing pin pair assignment can result in crossed pairs. Modular jacks and cross-connect blocks employ IDC connectors to complete the circuit between the cable and the hardware. The manufacturer will recommend the tools needed to terminate the cable.

Terminate with connecting hardware of the same category or higher. Any link that has substituted a lower category component is automatically classified to that lower category.

The maximum allowable amount of untwisting during cable termination to connecting hardware is 0.5" for Category 5e and Category 6 cables. Exceeding the recommended length of untwisting may cause performance problems. The same techniques should be employed when terminating cross-connect blocks. Maintaining jacket integrity to the point of termination aids in maintaining cable geometry and NEXT isolation from adjacent cable pairs.

Bridged taps and splices are not permitted as part of copper horizontal cabling requirements.

Testing

It is best to determine the lengths of several representative cable runs and adjust the NVP to correspond to the known cable lengths. If the readout for the cable length is longer than the known length, the NVP should be decreased. Conversely, if the readout for the cable length is shorter than the known length the NVP should be increased.

The NVP values for Mohawk's products are as follows:

	Non-Plenum	Plenum
Category 5e	68%	72%
Category 6	68%	72%

A Note of Caution:

Level II or Level III Testers will be required to accurately measure Category 5e and 6 permanent links and channels. Consult the manufacturer of your test set for clarification.

Category 5e and 6 - Permanent Link Requirements at Specific Frequencies

Freq (MHz)	Insertion Loss		NEXT	
	5e	6	5e	6
1.0	2.1	1.9	60.0	65.0
4.0	3.9	3.5	54.8	64.1
10.0	6.2	5.6	48.5	57.8
20.0	8.9	7.9	43.7	53.1
25.0	10.0	8.9	42.1	51.5
31.25	11.2	10.0	40.5	50.0
62.5	16.2	14.4	35.7	45.1
100.0	21.0	18.6	32.3	41.8
200.0	--	27.4	--	36.9
250.0	--	31.1	--	35.3

Freq (MHz)	ELFEXT		RL	
	5e	6	5e	6
1.0	58.6	64.2	19.0	19.1
4.0	46.6	52.1	19.0	21.0
10.0	38.6	44.2	19.0	21.0
20.0	32.6	38.2	19.0	21.0
25.0	30.7	36.2	18.0	19.5
31.25	28.7	34.3	17.1	18.5
62.5	22.7	28.3	14.1	16.0
100.0	18.6	24.2	12.0	14.0
200.0	--	18.2	--	11.0
250.0	--	16.2	--	10.0

The Permanent Link requirements include 90 meters of horizontal cable and the connectors at each end. The cables to the test equipment are not part of the permanent link and are subtracted out by the test equipment.

Channel requirements include 90 meters of horizontal cable and 10 meters of equipment cords, patch cords and jumpers. The maximum length of cross-connect jumpers and patch cords in the cross-connect facility should not exceed 5 meters.

For additional information and an ANSI referenced list, please contact: GLOBAL ENGINEERING DOCUMENTS at 1-800-854-7179.

For additional information on cable selection, please call 1-800-422-9961 or email techsupport@mohawk-cable.com.

These guides have been prepared by Mohawk as an aid for installers of Mohawk Category and Fiber Optic Cables and are not a warranty by Mohawk and should not be construed as such.

Mohawk's sole warranty with respect to its cables is set forth in the document entitled "Mohawk Warranty," which has been or will be provided separately to installers of Mohawk Category and Fiber Optic Cables.

Fiber Installation Guide

FOREWORD

It is assumed that the reader has a general understanding of fiber optic cable constructions and terminology. BICSI (www.bicsi.org) is an excellent resource for general information.

SAFETY PRECAUTIONS

- When installed on a live system, invisible laser radiation may be present. Do not stare into connector endface or view directly with optical instruments.
- Wear safety glasses when working with optical fiber.
- Dispose of all scrap fibers to avoid getting fiber slivers.

Scope

The following guidelines are intended as a general overview of important issues related to the installation of fiber optic cable.

INSTALLATION SPECIFICATIONS

For a proper cable installation, it is important to understand the cable specification. The two most important specifications are the tensile loading and bend radius specifications. It is very important to adhere to these limits.

Tensile loading

Although there are two different types of tension in fiber optic cables, the important tension for the installation is the maximum load the cable can be subjected to without causing permanent damage. We call it the "maximum load installation" and it is measured in Newton or pounds. The "maximum load installation" can also be known as "short term tension", "dynamic load", "installation load" or "installation tension".

Whenever possible, the tension of the installation should be monitored. The tension can be measured with a dynamometer, or with a pulling wheel. Breakaway pulling eyes are available which separate if the tension reaches a pre-set level. The use of a swivel is recommended when pulling the cable in tray. The swivel allows the cable and pulling rope to twist independently.

If pulling a cable in an outside plant conduit, the use of approved lubricants can help minimize friction. The use of corrugated innerducts can also help reduce the amount of tension needed to pull the cable. When installing

loose-tube cables, the use of sealer is recommended to prevent gel migration.

If a run is too long, or if several bends are in the conduit, intermediate pull boxes should be used to separate one pull into two or more shorter pulls. A cable should not be pulled through more than two 90° bends at one time. If three or more 90° bends in a continuous run are unavoidable, the cable should be installed from a central point, unreel into a figure-eight, and then back-fed to complete the installation. Sharp bends may increase cable tension, so it is best to install cable in sequences that minimize stress and labor costs.

When running cable vertically, take note of the cable weight. Install cables in a sequence that applies the least amount of strain on the cable. For example, most vertical chases in buildings tend to be congested at the lower floors; instead, try to start your installation at the top and work down the building, thereby eliminating most of the cable installation by the time you reach the lower floors. After installation, the strength member of the cable will need to support the hanging cable. If a long vertical run is necessary, cable should be secured at each floor and service loops should be placed every three floors, at a minimum. This procedure will help distribute the weight of the cable vertically and will facilitate access to moves, adds and changes (MACs), if needed at a later date.

Bend radius

There are two types of bend radius:

- The short term minimum bend radius, or dynamic bend radius, is the tightest recommended bend while installing cable at the maximum rated tension. It is the larger of the two specified bend radii. Throughout the pull, the minimum bend radius must be strictly followed. If a location exists in the middle of a run where a relatively tight bend is unavoidable, the cable should be hand-fed around the bend or a pulley can be used.
- The long term bend radius, or static bend radius, is the tightest recommended bend while the cable is under a minimum tension. It is the smaller of the two specified bend radii. After the pull is complete, the cable can be bent more tightly to fit into existing space, but not to exceed the long term minimum bend radius.

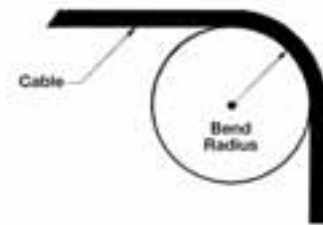


Figure 1: Bend Radius

Table 1: Typical Bend Radius Specification

	Short Term (Installation)	Long Term (Installed)
Outside Plant Cable	20x Cable Diameter	15x Cable Diameter
Premise Cable	15x Cable Diameter	10x Cable Diameter

Always follow the manufacturer's guidelines for minimum bend radius and tension. Failure to do so may result in high attenuation (macrobends) and possible damage to the cable and fiber. Guidelines are normally supplied with the cable manufacturer specification sheets. If the bend radius specifications are unknown, the industry de facto standard is to maintain a minimum radius of 20X the diameter of the cable.

The minimum bend radius must also be adhered to when using service loops. Fiber optic splice trays and patch panels are designed to accommodate the bend radii of the individual fibers, but outside of the hardware, extra care must be taken.

INSTALLATION TOOLS

Gripping Techniques

General

To effectively utilize all of the available strength in the cable, the strength member must be used. The manufacturer's specification will identify the strength member(s) in the cable.

Cables with aramid yarn as the strength member

For cables using aramid yarn alone as the strength member, the jacket can be removed exposing the aramid. The aramid should be tied in a knot with the pull rope, so that the jacket will not be inadvertently used for strength.

Optionally, the jacket can be tied into a tight knot before pulling. After pulling, the knot should be cut off.

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Figure 2: Distribution Cable Tied in a Knot

Cables with aramid yarn and an e-glass central member

For cables using aramid yarn and an e-glass central member, a pulling grip should be used. The strength member(s) should be attached independently. This can be accomplished by weaving the strength member into the fingers of the grip, and then taping it together. All strength members should be gripped equally to ensure a proper distribution of tension.



Figure 3: Pulling Grip

Pre-terminated Fiber Optic Cable Assemblies

General

The factory pre-terminated fiber optic cable assemblies may be specified in project environments such as Data Centers. The assemblies can be ordered in either indoor (plenum) or outdoor versions, and different fiber counts, and in multimode or single-mode. A pulling eye can be factory installed on either end or on both ends of the cable. The pulling eye (and associated cable netting) will protect the pre-terminated ends during the pull. This product is a great time saver ensuring quality connections every time.

Pulling eye

The pulling eyes (and associated cable netting) are highly recommended. The pulling eye will facilitate the installation as well as protecting the pre-terminated ends during the pull.

For both regular and pre-connectorized cables, the maximum pull force is identified with the "installation maximum load" cable specification on our data sheets.

In many cases, pulling is not done from point to point, but rather from an intermediate point pulling back in each direction to each termination location. It is then important to make sure that the cable is ordered with two pulling eyes, one at each end.

The installation of a cable, which is pre-connectorized on both ends, requires special

raceway considerations and pulling grips. A typical fiber optic connector is 0.5 in. (1.25 cm) in diameter, has a limited pull-off rating and must be protected during cable placement. A pulling grip for a pre-connectorized cable must successfully isolate the connectors from any tensile load by placing the load on the cable itself. The pulling grip must also protect the connectors from abrasion and damage. In medium fiber counts (6 to 24 fibers) the connectors must be staggered when installed to reduce the diameter of the pulling grip. In high-fiber counts (greater than 24 fibers), installation of a connectorized cable may not be possible due to the conduit size that would be required.

INSTALLATION GUIDELINES

Prior to installation

All optical fiber cables are tested before leaving our manufacturing plant. Before installing the cable, we recommend testing the cable on the reel for continuity. This is to ensure that no damage occurred during shipment. Since the cost of installation is usually higher than the cost of materials, testing the fibers before installation can avoid unnecessary additional expenses and help meet important deadlines. At a minimum, continuity testing can be done on the reel with a visual fault locator or a simple fiber tracer such as a flashlight, a modified flashlight to properly hold the fibers, a microscope or a bright red light (LED look-alike). With this simple test, you should be able to identify broken fibers, if any, within the optical fiber cable.

Also, it is recommended to double-check the actual fiber count and the actual cable length, to avoid any inconvenience.

It is preferable to use Velcro® wraps instead of tie-wraps. Remember not to distort the shape of the cable, as this adds pressure onto the optical fibers and may affect performance.

Fiber optic cables can be installed in innerducts. The use of innerducts tends to reduce the pulling tension required. Ensure that the properly rated innerduct is being installed.

A 3 to 6 m (10 to 20 ft) of cable slack should be stored in enclosure or on the wall to allow repairs and/or relocation needs.

Installation in Temperatures Below Freezing

The minimum installation temperature for plenum cables is 0° C (+32° F). If the cable has to be installed when the temperature is below +32° F the following precautions should be

taken to ensure that the jacket will not crack:

- Store the cable in a heated area whose temperature is above 50° F for 24 hours before installation.
- Transfer only enough cable to the job site for 4 hours work. The cable will retain enough heat to prevent cracking. Cable that has not been installed after 4 hours should be returned to a heated area.
- Coil service loops in 10" to 12" loops. A tight coil could cause the cable to crack.
- Normally the cables are terminated after the site is enclosed and heated. Do not attempt to terminate the cables when the temperature is below freezing.

OUTSIDE PLANT CABLE INSTALLATION

General

Protect exposed cables from vehicular and public traffic.

Underground Installation

For underground installation, center pull long cables. Store excess cable in vaults and manholes, and identify optical cables with markers.

Aerial Installation

Use proper hardware matching cable, span and tension requirements. Use correct cable jacket.

Buried Cable Installations

Identify cable locations with surface markers. Anticipate obstructions.

Administration

A unique identifier shall be assigned to each backbone cable and shall be marked on each end. Reference should be made as per the ANSI/TIA/EIA-606-A standard.

TERMINATION

General

Before termination, the cable should be properly secured to provide a tension-free length of fiber. When splicing fibers, mechanical or fusion, a splice tray is needed to properly store the completed splices. If connectors are to be used, trays or shelves should be used to support the fiber behind the connector. Proper strain relief sleeves provided with the connectors should always be used to prevent excessive bending of fiber. No shelf is necessary if terminating a breakout style cable with connectors.

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CABLE PREPARATION FOR THE TERMINATION

General

It is acceptable to directly terminate the 900 μm tight buffer from a distribution cable with a connector, if the above precautions are taken. It can be acceptable to directly terminate the 250 μm coated fiber from a loose buffer tube with a connector in certain applications. However, it is usually recommended to use a breakout kit which converts a six or twelve fiber loose buffer tube to a six or twelve fiber 900 μm distribution style ready for termination.

If outside plant cables are used, the gel flooding material (if present) needs to be cleaned with the appropriate solvent (please consult the cable manufacturer for recommendation on the choice of solvent). The more thorough the cleaning, the easier the termination procedure will be.

Cable preparation

To prepare the cable for termination, the outer jacket must be properly stripped. Two ring cuts should be made in the jacket; one about 2" from the end and the second at the point where the jacket is to be removed. Care must be taken not to cut all the way through the jacket and into the core. The 2" piece is removed from the end of the cable exposing the core and the aramid ripcord. Make a notch in the jacket alongside the ripcord (do not cut the ripcord!). Pull the ripcord with a needle-nose pliers, or similar, until it reaches the second ring cut. Remove the core from the sliced jacket and pull the jacket to tear it at the ring cut.

Once the fiber optic cable is ready for termination, follow the termination installation instructions.

TESTING

General

Once the cable plant is installed and terminated, it is recommended to test the fiber optic segment. The testing should be done according to TIA TSB-140. This document provides guidelines for field-testing length, loss and polarity of a completed fiber optic link.

It is necessary to perform an end-to-end attenuation test to verify the quality of installations and to ensure high quality system

performance. The best way to verify whether an end-to-end link meets the link loss budget is to divide the end-to-end link into segments at each cross-connect and measure the attenuation of each link segment. In order for the system to operate properly, the sum of the attenuation for the multiple link segments that form an end-to-end link must be less than the link loss budget calculated in the design phase.

Test equipment

Various types of testing equipment are available on the market, such as Optical Loss Test Set (OLTS), Visual Fault Locator (VFL) sets or the Optical Time Domain Reflectometer. For troubleshooting, the OTDR is recommended.

Optical Loss Test Set (OLTS)

The OLTS consists of a light source and an optical power meter. The main function of this equipment is to measure the optical power or loss.

Visual Fault Locator (VFL) or tracer

The VFL is a red laser source; the tracer is an LED source. Either instrument can be used to trace fibers and troubleshoot faults on optical fiber cables. The main function of this equipment is to check continuity of the fiber, as well as to identify fibers and connectors in patch panels or outlets.

Optical Time Domain Reflectometer (OTDR)

The OTDR is a more sophisticated measurement instrument. It uses a technology that injects a series of optical pulses into the fiber under test and analyzes the light scattering and the light reflection. This allows the instrument to measure the intensity of the return pulse in functions of time and fiber length. The OTDR is used to measure the optical power loss and the fiber length, as well as to locate all faults resulting from fiber breaks, splices or connectors.

Fiber testing guidelines

The following testing guidelines promote efficient and accurate testing:

- Clean all connections and adapters at the optical test points prior to taking measurements, as per ANSI/TIA/EIA-526-14A.
- The light source or OTDR (Optical Time Domain Reflectometer) must operate within the range of $850 \pm 30 \text{ nm}$, or $1300 \pm 20 \text{ nm}$ for multimode testing.

- Test jumpers must be of the same fiber core size, performance and connector type as the cable system (e.g., 50/125 μm jumpers for a 50/125 μm optical fiber system) and shall be one to five meters long. ANSI/TIA/EIA-568-B.1 is the recommended test method.

A detailed attenuation test report is available, upon request, for every reel of fiber optic cable shipped from Mohawk. Typical values for a multimode cable are 2.7 dB/km when measured at 850 nm and 0.7 dB/km when measured at 1300 nm. Therefore, for a run of 100 meters (328 feet), the typical cable attenuation is only 0.27 dB at 850 nm and 0.07 dB at 1300 nm.

Most fiber optic connectors are specified as having an insertion loss of less than 0.5 dB. Since there are two connections for each fiber, up to 1 dB of attenuation can be expected to be added to the installed cable. As the cable runs get shorter, the cable attenuation becomes lower, but the connector insertion loss remains the same. If the cable is installed properly, most of the measured attenuation will come from the connectors.

If several fibers off of the same cable show high attenuation, or if a single fiber attenuation remains high after retermination, an OTDR should be used to isolate the problem. An OTDR is an excellent tool for troubleshooting a failing link by identifying the location of the faulty component.

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