CHAPTER

9

EQUIPMENT INSTALLATION

This chapter includes the following topics:

9.1 INTRODUCTION

This chapter describes requirements and standard methods for communications equipment installation.

NOTE: The requirements described in this chapter **shall** be met before communications equipment is installed in site.

NOTE: This chapter assumes that all site and structure preparations have been performed (including battery systems, generators, line transient voltage suppression systems, tower systems, and site/structure grounding systems).

9.2 FACILITY READINESS

Following all construction work, both exterior and interior, the site and facility (structure or shelter) **shall** be in a suitable condition for installation of communication equipment. In general, the following considerations must be observed:

- Shelter exterior **shall** have final backfill and grade.
- Path between shelter and access road **shall** be free of trackable debris.
- Interior of facility **shall** be free of excessive dust or debris.
- Site exterior area **shall** have all refuse related to the installation tasks described in this manual removed before occupancy.

9.3 GENERAL CONSIDERATIONS FOR LAYOUT, WORK AREAS, AND SPACING

Consideration should be exercised when laying out a site to allow primarily for all code requirements for spacing, and then the most efficient use of space. Special attention **shall** be given to future expansion with regard to cable runway heights, electrical outlet placement, and equipment placement. Figure 9-1 shows proper equipment layout.

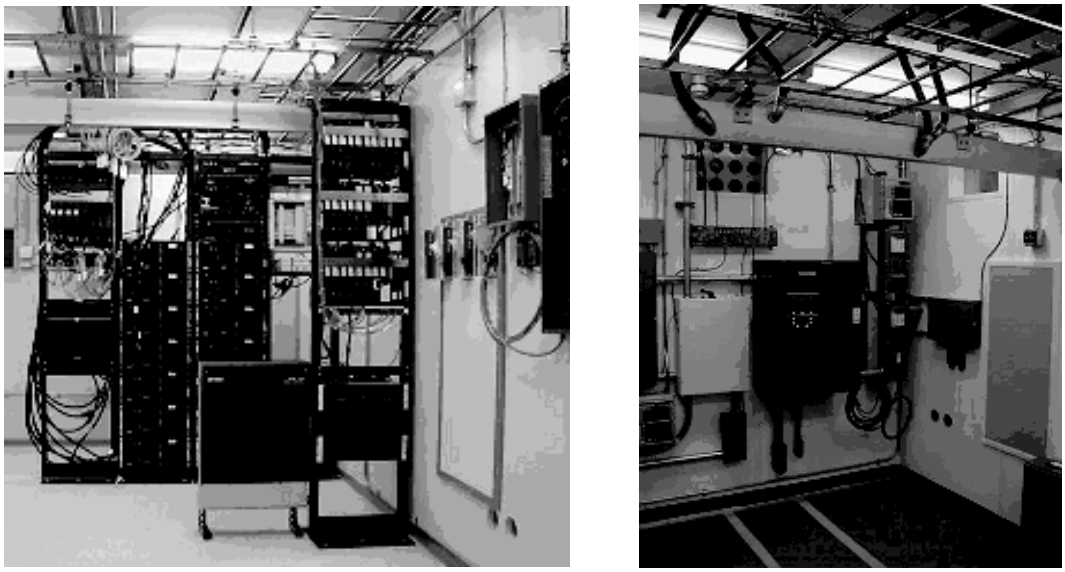


FIGURE 9-1 TYPICAL SITE INSTALLATION SHOWING PROPER EQUIPMENT LAYOUTS

9.3.1 SPACING REQUIREMENTS

Proper spacing of equipment is essential for efficient use of the room area, ease of maintenance, and safety of personnel. The following specifications have been established to meet the National Fire Protection Associations (NFPA) Code, and the American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE) standards. Any local regulations, as applicable, **shall** also be adhered to.

- To provide adequate working space, a 0.37 m^2 (576 sq in.) footprint (as measured from facing equipment surfaces) **shall** be used for combining equipment and upright base station equipment.

NOTE: Local codes may require additional clearance than stated above. In such cases, the local code **shall** prevail.

- A 914 mm (36 in.) side aisle **shall** be maintained around electrical panel boards (NFPA 70-2005, Article 110.26).
- A 914 mm to 1.2 m (36 to 48 in.) front, side, and (where applicable) rear aisles are required for servicing interior mounted air conditioners (NFPA 70-2005, Article 110.26, ASHRAE).

- A 762 mm (30 in.) aisle **shall** be maintained in front of all telephone switching equipment and/or demarcation cabling. A 914 mm (36 in.) aisle **shall** be maintained in situations where there is telephone switching equipment and/or demarcation cabling on both sides of the aisle (NFPA 70-2005, Article 110.72).
- A 762 mm (30 in.) minimum workspace **shall** be maintained on all non-egress or aisle ways without equipment described in this section.
- A 914 mm (36 in.) aisle **shall** be maintained between at least one end of an equipment row and building wall or other obstruction; longer aisles may require additional access breaks. Larger aisles and additional access breaks in a row may be required as the row becomes longer, such that a fire in the aisle does not prevent egress. Comply with any codes regarding fire egress specifications.
- Ingress and egress to equipment rooms **shall** conform with NFPA 70-2005 Article 110 and local building and fire codes.
- In US installations where a facility is to be normally occupied, American with Disabilities Act (ADA) **shall** be complied with. Some general requirements of ADA are 914 mm (36 in.) wide doors, ramps and safety rails, 914 mm (36 in.) turn-around clearance for wheelchairs, and specific placement of telephones, fire extinguishers, light switches, etc. Note that ADA compliance in architectural plans may be required in obtaining a construction permit in some localities.

9.4 SEISMIC CONSIDERATIONS

Site protection from earthquakes may be required in certain areas. Typically, this would be an area having historical data indicating a Moment Magnitude rating of 3 or 4. Note that areas other than historically prone areas may need consideration. Obviously, addressing such concerns results in increased costs of equipment installation.

A certified architect specializing in earthquake-resistant installation **shall** be consulted for seismic designs and recommendations in areas where the potential loss of the site may outweigh associated costs of earthquake-resistant design. In the United States, it is recommended to consult the US Geological Survey for additional information regarding earthquake probability and historical data for various areas. In other areas, similar consultation should be done.

NOTE: US Geological Survey information can be accessed at http://geohazards.cr.usgs.gov Seismic maps are available at: http://www.neic.cr.usgs.gov/

9.4.1 GENERAL RECOMMENDATIONS

Earthquake-resistant design should be contracted to a firm specializing in such work. Follow the design recommendations of the seismic engineering firm. In other cases observe the following general considerations:

- Equipment **shall not** be secured to both the shelter walls and floors, because dissimilar movement between these surfaces is likely in an earthquake.

- Mounting should provide for some “sway” in the overall equipment mounting, thereby absorbing the energy of an earthquake. This is typically accomplished by rigid mounting of racked equipment or cabinets at the base, while semi-rigidly attaching the rack top using 3.2 mm (0.125 in.) diameter steel braided wire rope. Wire rope anchors are then secured to ceilings joists. The benefit of this type of installation is that racks are allowed to sway within limits but can't fall over. Cables and transmission lines **shall** be installed to allow the equipment rack to sway.
- Cabinet designs with wide footprints can be used to help prevent cabinets from tipping over.
- Columns of cabinets stacked and bolted back-to-back present a very stable and wide footprint. The bottom cabinets **shall** still, however, be bolted to the floor for complete security.
- Some cabinets can be outfitted with outrigger-type support legs to prevent tip-over. These outriggers alone do not provide adequate earthquake protection, but are typically adequate if the cabinet is bolted to the floor.

NOTE: If a rack is seismic rated, any add-on aftermarket equipment or equipment that is not seismic rated will render the overall package as not being seismic tested and certified as a unit. Therefore, the unit would no longer be considered as seismic rated.

- All ancillary equipment that is not mounted in a rack or cabinet, such as CRTs or control stations, **shall** be securely fastened to a mounting structure.
- When bolting down to raised computer flooring, be sure to anchor all the way to the sub-floor.
- Columns of cabinets must be supported, though **not** rigidly. Rigid mounting will result in extreme vibration and resultant mechanical failure during an earthquake. Semi-rigid mounting is preferred. Semi-rigid bracing is defined as bracing which allows a measurable amount of movement.
- Some raised computer floors lose mechanical integrity if several panels are simultaneously removed. This could lead to equipment floor collapse during an earthquake. The flooring manufacturer **shall** be consulted for floor removal procedures. Raised flooring systems appropriate for the seismic zone **shall** be used.
- Equipment **shall** be stabilized by a top support. This is critical in preventing a column of equipment from toppling, causing injury to personnel. The footings of cabinet columns and racks **shall** be bolted to the floor as appropriate, using concrete anchors. Sometimes the cabinet columns are placed on C-channel tracks or wooden pedestals.
- Lighting fixtures should be prevented from swaying by addition of one or more guy wires. A fluorescent lighting fixture in particular, can be very dangerous if allowed to swing against a wall or equipment racks, shattering and spraying broken glass below. Fluorescent lighting fixtures **shall** have protective lenses or protective plastic sleeves which cover the fluorescent tube, preventing broken glass from falling on occupants.
- Storage cabinets **shall** be secured to prevent upset. Storage cabinets **shall** also have closable, secured doors to prevent contents from spilling during an earthquake.
- Ladders and other large objects **shall** be secured to a wall or removed from the equipment room when not in use. These items have been known to fall into “live” equipment during earthquakes.

9.5 EQUIPMENT MOUNTING PLUMB AND SQUARENESS

- Equipment **shall** be level and plumb. Equipment level **shall** be tested on a known flat surface in at least two directions to verify accuracy.
- Equipment **shall** be parallel or perpendicular to the surrounding walls and adjacent installed equipment.

9.6 EQUIPMENT ANCHORING

Anchoring is the mechanical fastening of the communications equipment to suitable locations using hardware acceptable for the application.

Although every installation is unique, certain methods for anchoring **shall** be adhered to for all installations. Typically, at least four anchor points **shall** be used on each item of equipment mounted to the floor. (The only exception is when the equipment manufacturer supplies other than four mounting points.)

NOTE: Where seismic concerns exist (Moment Magnitude rating 3 or greater), see "Seismic Considerations" on page 9-3 for additional information and requirements.

FIGURE 9-2 TYPICAL EQUIPMENT ANCHOR KIT

9.6.1 MOUNTING ON CONCRETE FLOORS

9.6.1.1 GENERAL REQUIREMENTS

Equipment racks or cabinets should be positioned and anchored to the floor using preferred mounting methods. Figure 9-3 on page 9-7 shows proper concrete mounting techniques and materials. In general, observe the following considerations:

- An anchor specifically designed for concrete **shall** be used. The preferred method for anchoring racks, or other ancillary equipment to concrete floors is to use flush-mount expansion anchors properly sized for the application. Flush mount expansion anchors do not extend above the surface of the floor and provide an easy bolt down. They also provide the required pullout and shear strength. If at a later time equipment needs to be moved, flush mount expansion anchors do not get in the way.

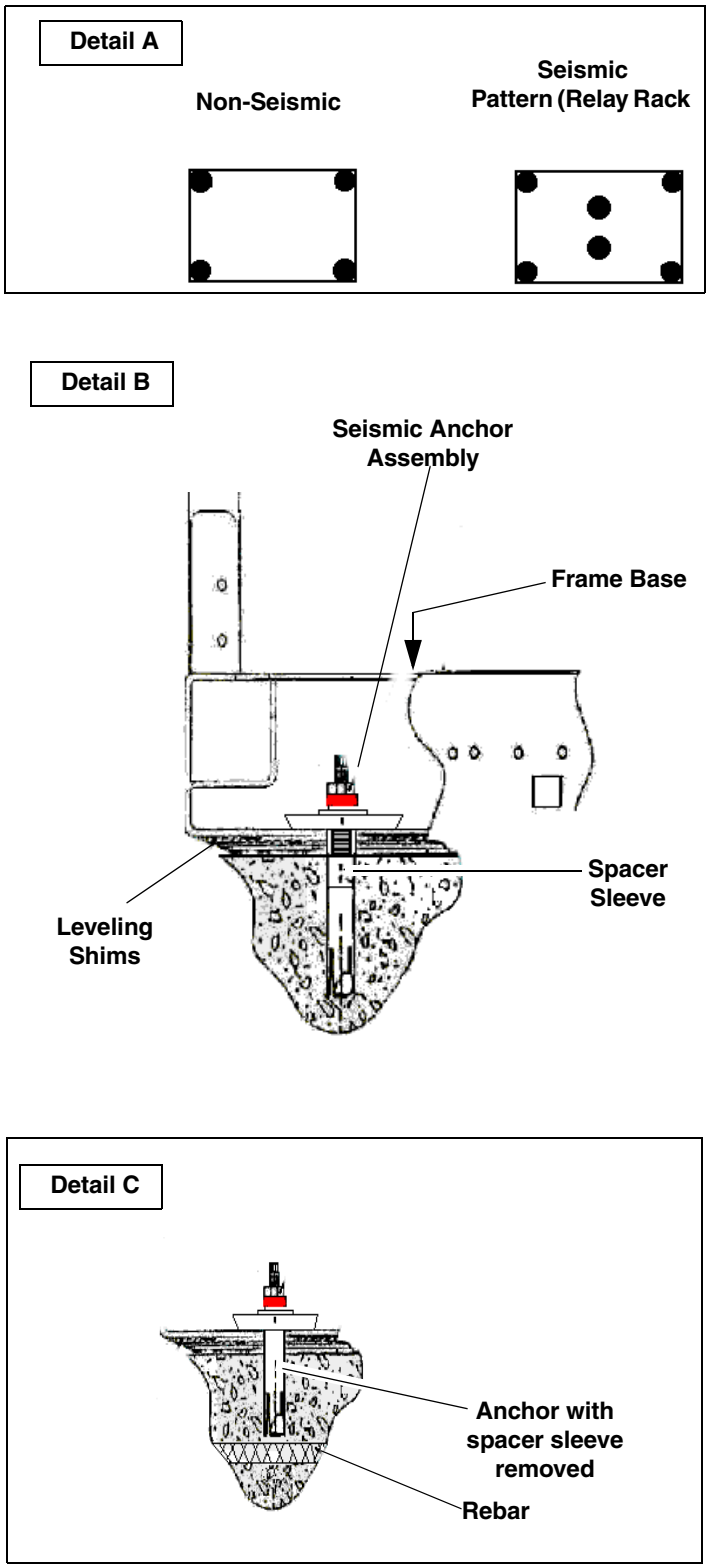
NOTE: Unless an isolating mounting scheme is used (see "Isolated Mounting" on page 9-8), ensure that no anchors come in contact with reinforcing rods or wire mesh buried in the concrete; the rack **shall** be electrically isolated from any other equipment or materials at the site.

- In applications where flush mount expansion anchors are not preferred or acceptable, then wedge-type stud anchors may be used.
- All concrete anchors **shall** be zinc plated carbon steel for standard applications, galvanized steel for mildly humid or corrosive environments, and yellow zinc or stainless steel for humid, highly corrosive, or acidic environments. Minimum bolt diameter **shall** be 10 mm (0.375 in.) with 12 mm (0.5 in.) preferred. Anchor embedment depth should be at least 76 mm (3 in.) to provide good tensile and shear strength. Follow manufacturer's instructions for depth reduction when rebar is encountered. A heavy duty washer should be part of the anchor assembly to ensure the equipment is secure.

9.6.1.2 SEISMIC ANCHORING

Seismic anchors are designed, tested, and specified for seismic zones 3 and 4. The use of seismic anchors enhance the stability of equipment due to the special characteristics specifically suited to the dynamic and cyclic loading effects experienced during earthquake events. As such, anchors **shall** be used that are manufactured to particular specifications that make them the most resistant to the effects of dynamic and cyclic loading effects. Selected anchors **shall** meet standards set forth in NEBS (Network Equipment Building Systems) TR-64 and ASTM (American Society For Testing and Materials) 488-90 for earthquake compliance. This testing evaluates anchors for bolt failure from shearing and from pullout or slippage. Compliance with these standards requires that the anchor not allow a standard top heavy 2.2 m (7 ft.) rack to have a deflection greater than 762 mm (3 in.) at the top of the frame. This compliance will also adhere to Bellcore Technical Specifications AU-434 for earthquake concrete expansion anchors.

Anchor selection criteria **shall** comply with all general requirements for standard concrete anchors plus meet the above seismic requirements. All seismic anchoring **shall** be enhanced with top cabinet or rack bracing.



NOTE: For seismic installation, concrete **shall** be a minimum of 206.73 MPa (3000 PSI or 2109.23 Tonnes/m^2) rating, at a minimum of 152.4 mm (6 in.) thickness (per Bellcore specification TR-64).

1. (See **Detail A**) Using appropriate pattern, drill 18 mm (11/16 in.) holes. Hole depth **shall** be 102 mm (4 in.) minimum below floor tile.
2. Vacuum all drilling dust, including the drilled holes, with a vacuum equipped with a 0.3 micron HEPA filter or better. Alternatively, place the vacuum outside and extend only the hose into the shelter. If any existing equipment is on site, cover it with an anti-static tarp or covering to prevent dust from entering.
3. (See **Detail B**) Insert anchors into hole until plate washer is flat against floor surface.
4. Tighten anchor nuts to a torque of 67.8 Nm (50 lb ft.).
5. Break nuts loose and remove rods using the 1/4-in drive top.
6. Place cabinet in mounting position.
7. Re-insert threaded rods with stack-up parts into holes. Hand-tighten nuts.
8. Using a wrench, tighten nuts until the tops of torque nuts twist off (between 1/4 and 1/2 turn).
9. If rebar is encountered with the standard anchor, remove the spacer (See **Detail C**). With spacer removed, reinstall the anchor. (Length of threaded rod can be altered, as required.)

FIGURE 9-3 CONCRETE MOUNTING USING CONCRETE ANCHORS

9.6.1.3 ISOLATED MOUNTING

Isolated mounting is recommended to prevent a second path to ground (ground loop) through the concrete floor, and is required for the installation of certain equipment. In these cases, expansion anchors are inserted into the concrete floor. However, isolation of the equipment rack is ensured using an insulating plate and hardware as shown in Figure 9-4. If the installation is in an earthquake zone, additional anchors are used as shown in Figure 9-4.

NOTE: The isolation plate should be made of a insulating material such as fiberglass or polypropylene plastic that will not deteriorate in varied temperature ranges.

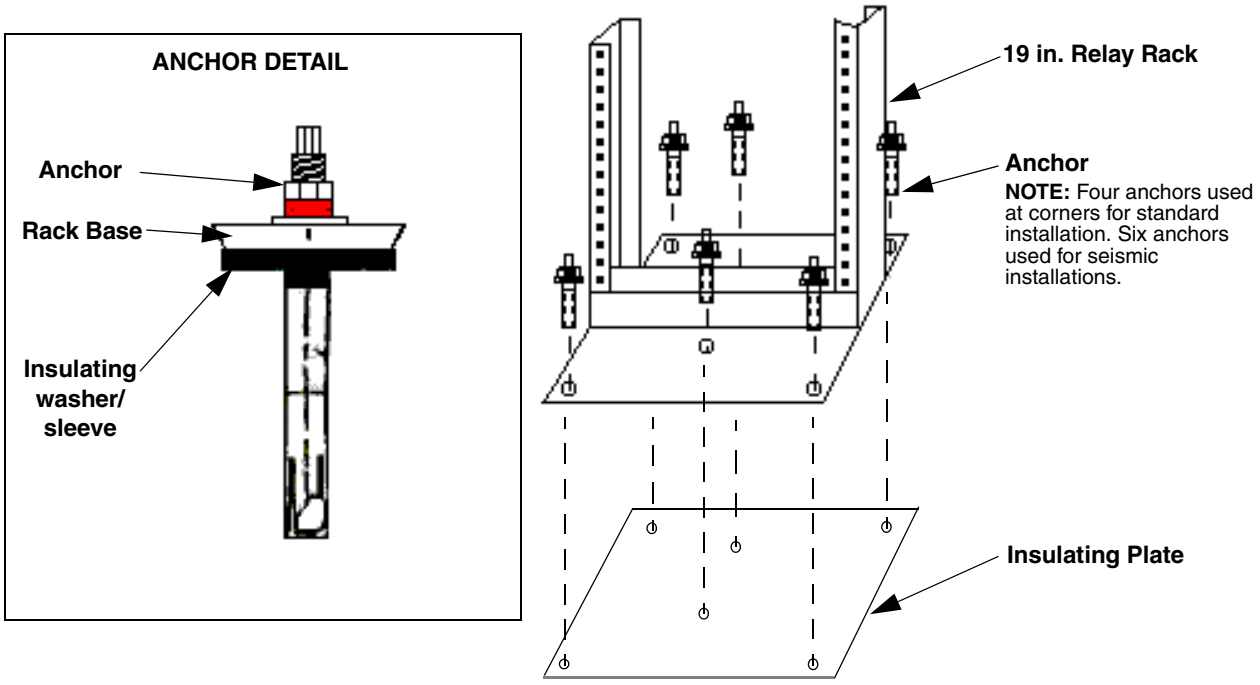


FIGURE 9-4 ISOLATED MOUNTING SYSTEM

9.6.2 MOUNTING ON WOOD OR FIBERGLASS FLOORS

Appropriately sized lag bolts **shall** be used for mounting on wood or fiberglass floors. If the underside is accessible and the floor stability is questionable, then thru-bolting may be desirable.

It is recommend to mount base stations and other non-racked ancillary equipment on a "C-channel" type of mounting track where possible. This provides for easy cleaning and some isolation in the case of standing water. Another benefit of installing non-rack mounted equipment off the floor, is that the weight is distributed across the floor. In these cases, C-channel type mounting provides multiple floor anchor points where the equipment provides only four to six anchor points.

9.6.3 ANCHORING EQUIPMENT TO RAISED FLOORS

At least four anchor points **shall** be used on each item of equipment mounted to the floor. The only exception is when the equipment manufacturer supplies less than four mounting points. When mounting racks to raised floors, 13 mm (0.5 in.) minimum diameter allthread rod and flush mount expansion anchors **shall** be used to anchor to the concrete sub-floor. When mounting equipment to a raised floor, 10 mm (0.375 in.) minimum allthread rod and hardware **shall** be used for anchoring. Mounting arrangement **shall** be in accordance with rack manufacturer's instructions.

Sandwich the computer floor and equipment rack with nuts and washers as shown in Figure 9-5. When mounting consoles to a raised floor, 10 mm (0.375 in.) minimum diameter allthread rod **shall** be used for anchoring.

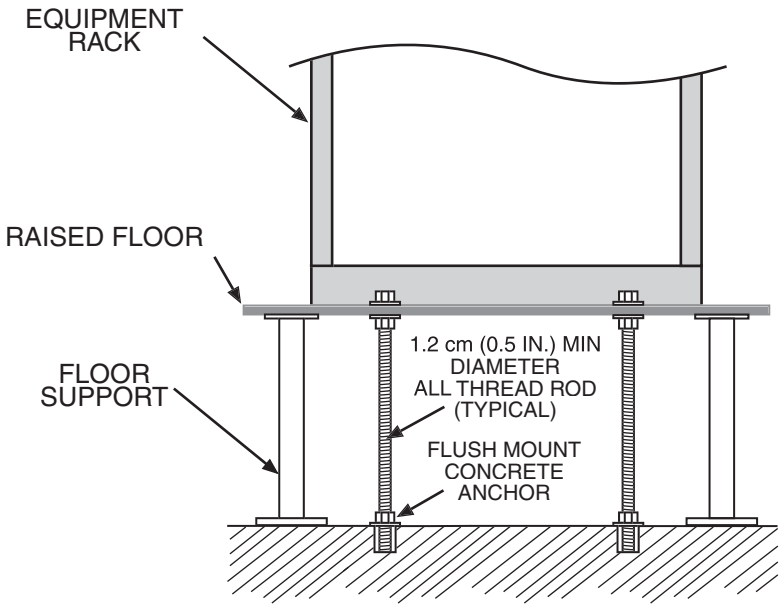


FIGURE 9-5 ANCHORING EQUIPMENT TO RAISED FLOORS

9.6.4 ANCHORING OVERHEAD AND WALL-MOUNTED EQUIPMENT

The anchoring of overhead and wall-mounted devices present a number of considerations. Placement is very important; if equipment is bolted to a wall that is on an aisle, the aisle may be unacceptably narrowed with the danger of injury to personnel. Also, the serviceability of the equipment being mounted to adjacent equipment may be inhibited.

Overhead applications generally include coax cabling, cable runways, and mounts for earthquake bracing. All overhead applications should keep in mind loading of overhead surfaces. Care must be exercised when deciding how much can be held up by the ceiling without some sort of building foundation support. In the case of earthquake bracing equipment (discussed in "Seismic Considerations" on page 9-3), cable trays can be secured overhead then affixed to the equipment racks providing acceptable foundation support.

When anchoring cable trays to ceilings or walls, the manufacturer-supplied support hardware **shall** be used.

Anchors used in overhead applications vary depending on the ceiling structure as follows:

- For concrete and wood ceilings, the same principles discussed in floor anchoring apply.
- For an exposed steel I-Beam ceiling, many cable runway manufacturers make beam clamps for C-channel or threaded drop rods.
- For corrugated steel ceilings, C-channel tracks can be affixed to the ceiling using properly sized lag bolts. The C-channel will span the corrugated steel and provide multiple anchor points.

For drywall or plasterboard ceilings, special considerations are required:

- If the drywall is on steel or wooden roof joists, locate and tap into the roof joists with lag bolts.
- C-channel mounting can be used.
- An alternative to C-channel mounting is using large toggle or molly wings with hex head tap bolts.

NOTE: Make certain joists are properly located before drilling into drywall. If any existing equipment is on site, ensure it is covered with an anti-static tarp or covering.

9.7 EQUIPMENT INSTALLATION WITHIN RACKS OR CABINETS

Most communication equipment is mounted into standard 19-in EIA racks or enclosed cabinets. Follow the rack and/or equipment manufacturer's instructions when installing equipment into racks or cabinets.

- All supplied bracing hardware **shall** be properly utilized.
- Proper hardware **shall** be used to secure equipment.
- See Chapter 5 for proper equipment grounding.
- Convected heat transfer from one piece of equipment rack to another **shall** be considered. Heat baffles or fan kits may be required.

WARNING

Do not mount heavy equipment at the top of the equipment rack or cabinet. It may cause the rack to become top-heavy and unstable.

9.8 ANCILLARY EQUIPMENT MOUNTING

Any permanent site equipment that is not rack- or cabinet-mounted, should be permanently secured or mounted, including items placed on rack- or cabinet-mounted peripheral trays.

9.9 EQUIPMENT CABLING

This section describes requirements for cabling within equipment cabinets and racks, and requirements for cable runs between equipment cabinets/racks. Cabling within racks and cabinets **shall** conform to the requirements of NFPA 70-2005, Article 300, Article 800, Article 810, Article 820, and Article 830. (See ANSI/TIA/EIA-568(b) and 569(b) and NECA/BICSI 568-2001 for additional information.)

9.9.1 CABLING REQUIREMENTS FOR EQUIPMENT IN RACKS AND CABINETS

All cables **shall** be installed and routed so that personal safety and equipment functionality is not compromised and that all equipment is accessible for servicing. The following requirements apply to cabling installed in racks or cabinets:

9.9.1.1 SECURING CABLES WITHIN RACKS OR CABINETS

- To help prevent damage or accidental disconnection, cables and conductors **shall** be secured at intervals of no more than 914 mm (3 ft.). Attachment **shall** be accomplished in a manner that does not restrict access to the equipment in the rack or cabinet.
- Insulated standoffs are recommended for use in racks or cabinets. The standoffs should be of sufficient length to maintain the proper cable separation.
- Nonmetallic cable ties **shall** be used to secure cables and conductors. Attachment **shall** be tight enough to secure cables without crushing or deforming them.
- Nonmetallic cable ties must be cut with flush cut sidecuts directly adjacent to the locking tab to prevent sharp protrusions.

9.9.1.2 ROUTING CABLES WITHIN RACKS AND CABINETS

- Grounding conductors within racks or cabinets **shall** be routed toward the RGB, MGB, SSGB, or ground bus conductor. Connections to the RGB or ground bus conductor **shall** always be made with the equipment grounding or tap conductors being routed toward the MGB, SSGB, or RGB. See Figure 5-17 on page 5-24 for an example.
- Whenever possible, cable groups of different types should maintain 50.8 mm (2 in.) separation when passing through the cabinet housing. When the 50.8 mm (2 in.) separation cannot be maintained at the through the cabinet housing penetration, separation **shall** be maintained before and after the penetration point. See Figure 5-14 on page 5-22 for an example.
- Cables in racks or cabinets **shall** be sized to length, and **shall** be installed and routed neatly and in a workmanlike manner.
- AC power cords longer than necessary may be looped down and back up a rack or cabinet. Excess lengths of AC power cord **shall not** be coiled on top of racks or cabinets.

9.9.1.3 PROTECTING CABLES WITHIN RACKS AND CABINETS

- Where cables or conductors are routed through holes in metallic surfaces or near sharp edges, the sharp surfaces **shall** be suitably protected with a grommet or similar material to help protect the cable or conductor from damage caused by sharp edges.
- Ensure cables ar not crimped or bent when cabinet doors are opened or closed.

9.9.1.4 CABLE BENDING RADIUS WITHIN RACKS AND CABINETS

- Grounding conductors of all sizes **shall** maintain a minimum bending radius of 203 mm (8 in.). The angle of any bend **shall** be not less than 90 degrees.
- The bending radius of CAT-5 cables **shall** be not less than 10 times the outside diameter of the cable. Follow the cable manufacturer's recommendations and see ANSI/TIA/EIA-568(b) and CSA-T529-1995 for additional information.
- All other cables **shall not** have sharp bends which will damage or degrade the performance of the cable. The cable manufacturer's specifications **shall** be followed.

9.9.1.5 CABLE SEPARATION AND GROUPING WITHIN RACKS AND CABINETS

- Cabling in racks or cabinets **shall** be grouped according to function. Groups are defined as:
  - AC power cords
  - DC power cables
  - Ground conductors
  - RF transmission cabling
  - Data, control, signal and timing reference cabling and telephone cabling
- Cable groups within racks and cabinets **shall** be separated by 50.8 mm (2 in.) from other cable groups. See ANSI/TIA/EIA-568(b) and -569(b); and NFPA 70-2005, Articles 800.133, 810.18, 820.133 and 830.133 for additional information.
- When practical, cable groups at or in close proximity to equipment chassis should be separated by 50.8 mm (2 in.) or cross at a 90 degree angle.

9.9.2 COMMUNICATION CABLING REQUIREMENTS FOR PLENUMS AND OTHER AIR-HANDLING SPACES

WARNING

Non-plenum rated power cabling shall not be installed within plenums. Failure to use plenum-rated cables in these areas can result in generation of toxic fumes in the event of a fire.

NOTE: Feasibility and methods of wiring within plenums and risers **shall** conform with jurisdictional codes.

The following requirements specify installation practices that help, should a fire occur, minimize smoke and products of combustion from electrical wiring in areas that handle environmental air. A plenum is defined as a compartment or chamber to which one or more air ducts are connected and that forms part of the air distribution system. See NFPA 70-2005, Article 100 for additional information.

- Wiring systems of any type **shall not** be installed in ducts used to transport dust, loose stock, or flammable vapors (NFPA 70-2005, Article 300.22(A)).
- Wiring systems of any type **shall not** be installed in any duct, or shaft containing only such ducts, used for vapor removal (NFPA 70-2005, Article 300.22(A)).

- Wiring systems may be installed in ducts specifically constructed to transport environmental air only when such wiring consists exclusively of the following. See NFPA 70-2005, Article 300.22(B) for additional information:
  - Type MI (mineral insulated) cable
  - Type MC (metal-clad) cable employing a smooth or corrugated impervious metal sheath without an overall nonmetallic covering
  - Type CMP (communications plenum cable), electrical metallic tubing, flexible metal tubing, intermediate metal conduit, or rigid metal conduit. Flexible metal conduit and liquid-tight flexible metal conduit **shall** only be permitted in lengths not exceeding 1.22 m (4 ft.), to connect physically adjustable equipment and devices permitted to be in the ducts. See NFPA 70-2005, Article 300.22(B) for additional information.
- Wiring installed in other spaces used for environmental air, such as the area above a suspended ceiling or as otherwise defined in NFPA 70-2005, Article 300.22(C), **shall** be installed in accordance with NFPA 70-2005, Article 300.22(C). Such wiring methods include using Type MI (mineral insulated) cable, Type MC (metal-clad) cable without an overall nonmetallic covering, and Type AC (armored cable) cable. See NFPA 70-2005, Article 300.22(C) for additional information.

WARNING

Electrical installations installed in hollow spaces, vertical shafts, and ventilation or air-handling ducts shall be installed in a manner such that the possible spread of fire or products of combustion will not be substantially increased. Openings around penetrations through fire resistance-rated walls, partitions, floors, or ceilings shall be firestopped using approved methods to maintain the fire resistance rating. Firestopping such penetrations may be accomplished by using specially manufactured fire seals or fire-barrier caulking. See NFPA 70-2005, Article 300.21, ANSI/TIA/EIA-569(b), and NECA/BICSI 568-2001 for additional information.

- Communications cables installed in vertical runs spanning more than one floor, or cables installed in vertical runs in a shaft **shall** be Type CMR (Communications riser cable) or Type CMP (NFPA 70-2005, Article 800.154(B)).
- A bare grounding conductor may be installed in a plenum area. If a bare conductor is used, it **shall** be properly secured and protected from making incidental contact with other metallic objects not meant to be bonded to the grounding conductor. Plenum-rated insulated sleeving may be used to prevent incidental contact.
- See NFPA 70-2005, Article 645 for details on Information Technology equipment room wiring.

9.9.3 CABLING REQUIREMENTS FOR CABLE TRAYS OR LADDERS

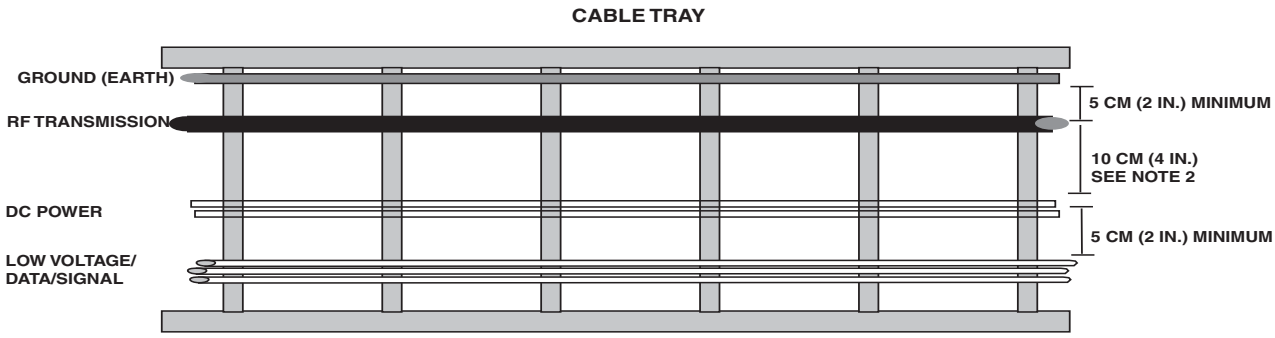
9.9.3.1 CABLE INSTALLATION WITHIN CABLE TRAYS OR LADDERS

- Cables that span a horizontal gap greater than 610 mm (2 ft.) **shall** be supported.
- When installing cables into a cable tray system, cables **shall not** be pulled with such force that the conductor insulation or cable jacket integrity is destroyed or that the cable is deformed.
- Antenna and transmission lines minimum bending radii **shall** be considered when placing these cables within the cable tray. Follow manufacturers' specifications.
- Cables installed within a cable tray system **shall** be fastened securely to transverse members in all horizontal and vertical runs every 914 mm (36 in.).
- The most desirable method to exit the cable runway is to drop out the bottom into a rack/cabinet or a vertical support such that physical separation is maintained.
- AC power cables **shall not** be run within a cable runway system unless they are enclosed within metallic conduit or raceway.

NOTE: Raceways or conduit installed below or along side cable runways may not be supported by the cable runways themselves unless the cable runway system is designed to provide such support.

9.9.3.2 CABLE SEPARATION AND GROUPING WITHIN CABLE TRAYS

- Cable groups **shall** be separated a minimum of 50.8 mm (2 in.) from other cable groups. (See ANSI/TIA/EIA-568(b) and 569(b); NFPA 70-2005, Articles 800-133, 800-18, and 820-133 for additional information.)
- Transmission lines (coax) for transmitting stations **shall** be separated a minimum of 101 mm (4 in.) from electrical lights, power, and signaling circuits (NFPA 70-2005, Article 810.70).
- Groups are defined as:
  - AC power, DC Power, ground conductor and RF transmission cabling
  - Data, control, signal and timing reference cabling
  - Telephone cabling
- At a minimum the above group separation must be maintained. However with adequate cable tray space, logical sub-groups are permitted such as, bundles of DC cabling, bundles of RF cabling, etc.
- AC power cables cannot be run in the same cable tray as CAT-5 or communications cables unless separated by a barrier as defined by NFPA 70-2005. (See "Computer Network Cabling" on page 9-18 for additional information.)



NOTES:
1. Each cable type may be single or multiple cables of the same type grouped together.
2. If the ground conductor is installed on the outside of the rack, coaxial RF transmitting cable shall be 10 cm (4 in.) away from any other cables (power and low voltage) as described in NFPA 70-2005, Article 810.70. Receiving coaxial RF cables require a 5 cm (2 in.) separation.

FIGURE 9-6 MINIMUM CABLE GROUP SEPARATION IN CABLE TRAY

9.9.3.3 SECURING CABLES WITHIN CABLE TRAYS

- Cables and conductors **shall** be secured at intervals of no more than 914 mm (3 ft.).
- Nonmetallic cable ties **shall** be used to secure cables and conductors. Attachment **shall** be tight enough to secure cable, yet not crushing or deforming the cable.
- Cables running vertically on a cable ladder **shall** be secured at a minimum of 914 mm (36 in.). It is preferable to secure them at every rung, but not required.
- When cables span a gap (such as between a cable tray and a ladder) in excess of 610 mm (24 in.), the cables **shall** be supported.
- Certain telephony requirements may exist for cables to be laced. See "Cabling in Telephone Wiring Environments" on page 9-28 for additional information.
- Cable **shall** be sized to length including a sufficient service loop. Excess cable **shall not** be coiled on top of cabinets or cable trays.
- Communications cables **shall not** be attached by any means to the exterior of a conduit or other raceway as a means of support (NFPA 70-2005, Articles 725.58 and 800.133(C)).
- Communications cables **shall not** be laid directly on the tiles or grid work of a false ceiling (ANSI/TIA/EIA-569(b)), NFPA 70-2005, Article 725.7, 800.21, and 820.21).

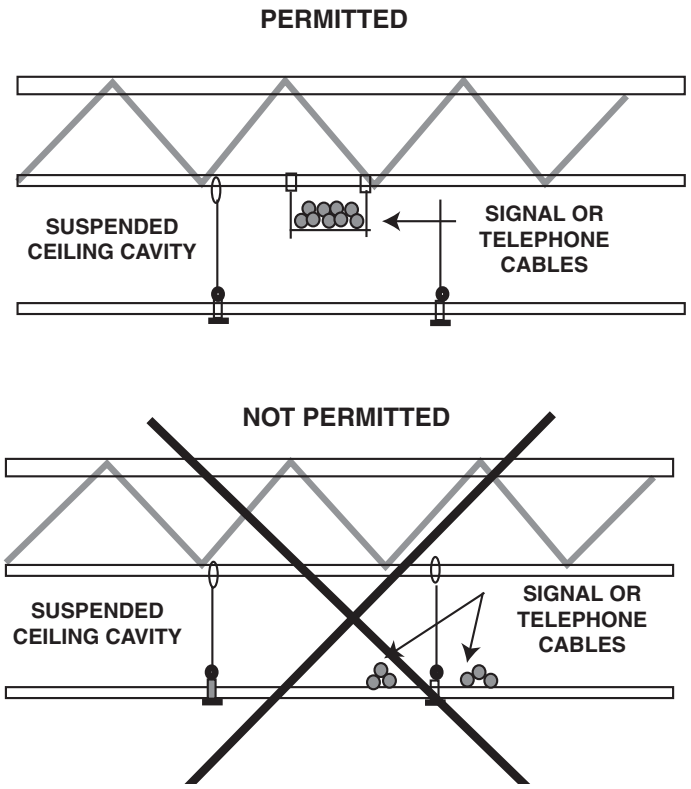


FIGURE 9-7 COMMUNICATIONS CABLES IN SUSPENDED CEILINGS

9.9.4 AC POWER CABLING

WARNING

Facility AC wiring within junction boxes, receptacles, and switches shall be performed by a licensed and bonded electrical contractor. Personnel safety and liability hazards can result from AC wiring performed by installation personnel other than an electrical contractor.

When an open equipment rack is used, hardwiring of power is not always possible. Mounting a dedicated simplex receptacle or receptacle assembly on the rack may be the most convenient method of supplying power, especially if multiple pieces of equipment are mounted on the rack.

These receptacle assemblies can be pre-manufactured and mounted to the top face of an equipment rack. Mounting can also use a fabricated power pole mounted between racks.

WARNING

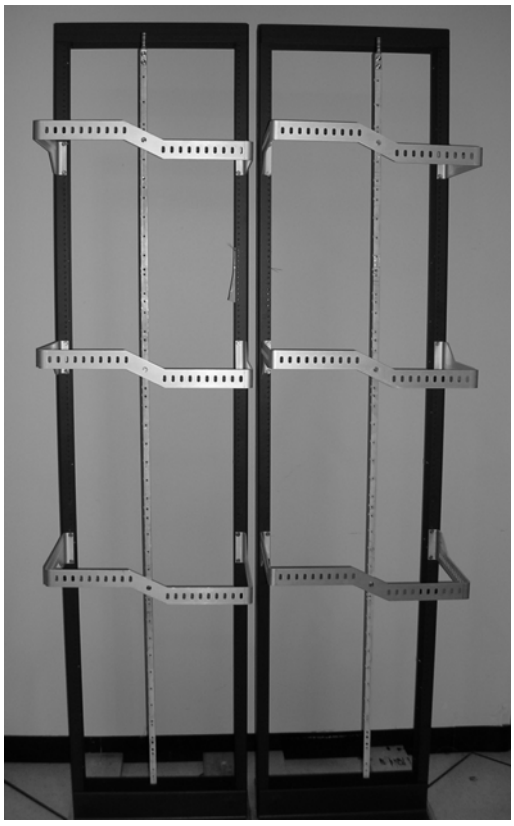
Under no circumstances shall consumer-grade power outlet strips be used in any installation. Extension cords of any type shall not be used for connecting line power to communications equipment.

9.9.5 DC POWER CABLING

In telecommunications environments, common DC systems are as follows:

- +12 volt systems
- +24 volt systems
- -24 volt systems
- -48 volt systems

Traditional wireline telephone offices most often use -48V, sometimes called -BATT voltage, whereas many cellular, PCS, and other radio systems use +24 to 27 V. There are also instances of -24V systems. In U. S. installations, the most common practice is to use red cabling for the sourcing, fused, ungrounded, "hot" terminal. Black cabling is used for the return, unfused, grounded, terminal. (European installation practice uses blue insulation for the "hot" lead.) Chapter 8, "Power Sources," discusses power cabling sizing and other installation concerns. The manual for the equipment being installed will also have specifications stating the cabling size required. Careful consideration must be given to cable size and length. See Chapter 6, "Power Sources" and cabling capacity for further information.



FRONT VIEW

SIDE VIEW

FIGURE 9-8 CABLE MANAGEMENT SYSTEM WITH INTEGRATED RACK GROUND BUS BAR

9.9.6 COMPUTER NETWORK CABLING

Computer network cabling typically consists of Category 5 (CAT 5) cabling terminated with 8-pin modular connectors.

The proper installation of computer network cabling is critical to the safe and reliable operation of the computer network. It is recommended that standards developed by the Telecommunications Industry Association/Electronic Industries Association (TIA/EIA) and the Canadian equivalent (or equivalent standards in other countries) be followed. Applicable NFPA codes, local electrical codes, local building codes and other standards in this manual **shall** also be conformed to when installing computer network cabling.

NOTE: It is recommended that computer network cable installations be performed by a specialist in the installation of computer networks. The specialist should have the expertise, knowledge of applicable local codes, and the test equipment required for a quality installation.

NOTE: This section cites standards from the American National Standards Institute (ANSI), the Electronic Industry Association (EIA), the Telecommunications Industry Association/Electronic Industries Association (TIA/EIA, and the Canadian Standards Association (CSA). These standards should be followed even for sites located outside the U.S.

9.9.6.1 CABLE TYPE

CAT 5 Unshielded Twisted Pair (UTP), 100-ohm cable is the recommended cable type for computer network cabling, and will be the assumed cable type throughout this section. CAT 5 cable is preferred over CAT 3 and CAT 4 cables because of its ability to support 100Mbps (Megabits per second) systems and because of its improved immunity to Electromagnetic Interference (EMI) and Radio Frequency Interference (RFI). See American National Standards Institute/ Telecommunications Industry Association/ Electronic Industries Association ANSI/TIA/EIA-568-B and Canadian Standards Association CSA-T529 for additional information.

9.9.6.2 CONNECTING HARDWARE

UTP cables **shall** be terminated with connecting hardware of the same category rating or higher. This includes all connectors, punch blocks, cross-connect jumpers and patch cords. It is recommended that hardware used to terminate cables be of the insulation displacement (IDC) type. Modular connectors **shall** also be of the proper typed for the cable used; solid conductor cable uses a different connector than stranded cable. See ANSI/TIA/EIA-568-B and CSA-T529 for additional information.

9.9.6.3 CABLE AND CONNECTOR WIRING

Appropriate color-coding and jack pair assignments should be followed when wiring modular jacks, connectors, and cables. The same wiring standard **shall** be used throughout the cabling system. ANSI/ TIA/EIA T568A and T568B are the recommended standards. Figure 9-9 shows the color coding and Figure 9-10 shows end views of an 8-pin modular female jack for both standards with the pairs and colors identified. See ANSI/TIA/EIA-568-B and CSA-T529 for additional information.

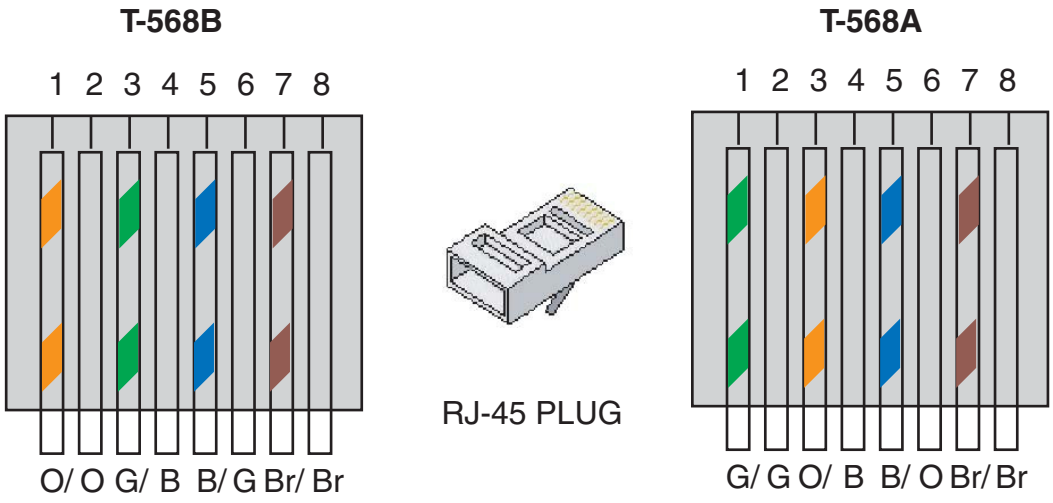
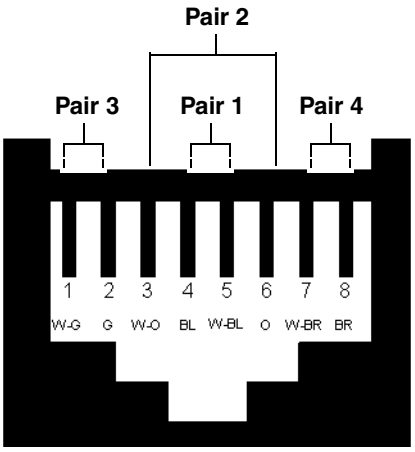
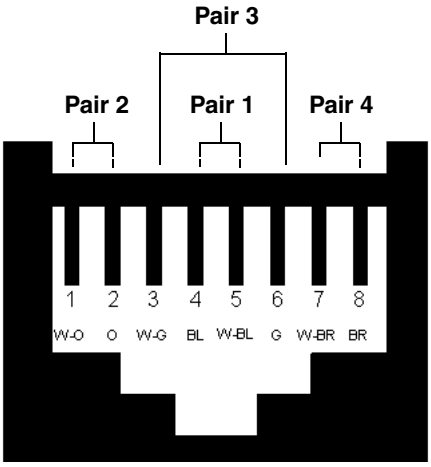


FIGURE 9-9 RJ-45 COLOR CODING



Cable Pair	Color
1 (term 4, 5)	white-blue (W-BL) blue (B)
2 (term 3, 6)	white-orange (W-O) orange (O)
3 (term 1, 2)	white-green (W-G) green (G)
4 (term 7, 8)	white-brown (W-B) brown (BR)

T568A Connections



Cable Pair	Color
1 (term 4, 5)	white-blue (W-BL) blue (B)
2 (term 1, 2)	white-orange (W-O) orange (O)
3 (term 3, 6)	white-green (W-G) green (G)
4 (term 7, 8)	white-brown (W-B) brown (BR)

T568B Connections

NOTE: For both connectors, female jack is shown (view from FRONT (mating) end of connector shown

FIGURE 9-10 8-PIN MODULAR JACK PINOUT

9.9.6.4 CABLE INSTALLATION AND ROUTING

Observe the following additional considerations for network cabling in addition to the general requirements throughout the rest of this manual:

- Consideration should be given to using some method of cable management and containment for runs of CAT 5 cable. Such methods can be dedicated cable runs, lay-in wireways, cable trays and conduits. See ANSI/TIA/EIA-569-B and CSA-T530 for additional information.
- CAT 5 cable **shall not** be installed in the same conduit, cable tray, outlet box, or similar device with AC power cables, unless separated by a barrier as allowed in NFPA 70-2005, Article 800-52. Doing so can be unsafe and is likely to cause EMI onto the CAT 5 cable, causing network errors. See NPFA 70-2005, Article 800.133, ANSI/TIA/EIA-568-B, 569-B, and CSA-T529, T530 for additional information.
- Avoid routing CAT 5 cable near sources of EMI/RFI. Such noise sources may be electrical power wiring, dimmer switches, radio frequency transmitters, motors, generators, and fluorescent lights. Precautions include increasing the physical distance between the CAT 5 cable and the source of the EMI/RFI; installing the cable inside a grounded metallic conduit; or use of a CAT 5 100-ohm screened twisted pair cable as permitted by ANSI/TIA/EIA-568-B. Routing cables near sources of EMI/RFI can cause data errors and degraded system performance. See ANSI/TIA/EIA-568-B, 569-B and CSA-T529, T530 for additional information.
- Cables **shall** be separated by at least 50.8 mm (2 in.) from AC power conductors. See NPFA 70-2005, Article 800.133 for additional information.
- CAT 5 cables installed in ducts, plenums, and other air-handling spaces **shall** be installed in accordance with other chapters of this manual and NFPA 70-2005, Article 300.22. See also NFPA 70-2005*,* Article 645.
- CAT 5 cables installed in hazardous areas as defined in NFPA 70-2005, Article 500 **shall** be installed in accordance with NFPA 70-2005, Article 500 and any other applicable electrical and building codes.
- CAT 5 cable **shall not** be attached by any means to the exterior of a conduit or other raceway as a means of support. See NFPA 70-2005, Article 725.58 and NPFA 70-2005, Article 800.133 for additional information.
- Suspended ceiling support rods and wires may be used as a means of support for computer network cabling if used in conjunction with appropriate cable fasteners. See ANSI/TIA/EIA-569-B and CSA-T530 for additional information.
- CAT 5 cables **shall not** be laid directly on the tiles of a false ceiling. See Figure 9-7. (ANSI/TIA/EIA-569(b)), NFPA 70-2005, Article 725.7, 800.21, and 820.21).
- CAT 5 cables **shall not** be run from one building to another building. If the computer network must be extended to another building, a specific cabling system **shall** be engineered. Options for extending from one building to another may include the use of fiber optic cable or a T-1. Computer network cabling entering and/or leaving a building **shall** be properly grounded and protected from surges as required elsewhere in this manual.

9.9.6.5 INSTALLATION PRACTICES

- Avoid unnecessary junction points and cross-connects. Every added junction point and cross-connect can decrease the performance of the network.
- Multiple appearances of the same cable at different locations, referred to as bridge taps, **shall** be avoided (see Figure 9-11). Each cable segment **shall** have only one source and one destination.

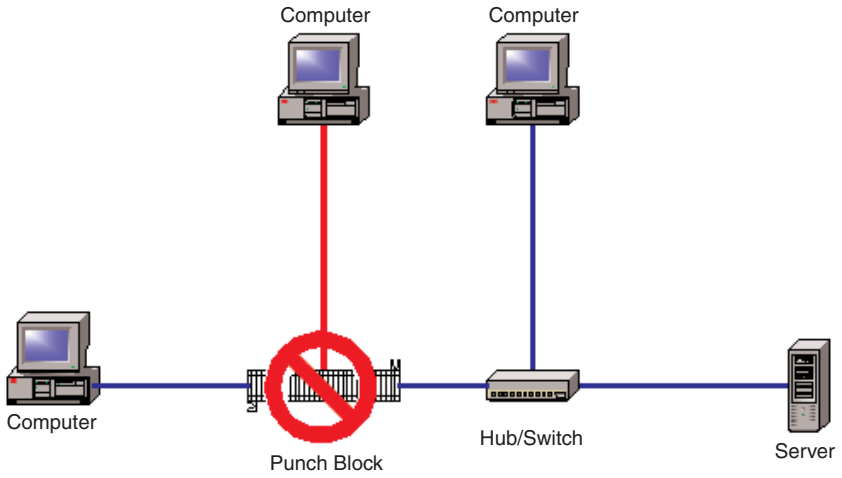


FIGURE 9-11 DISALLOWED "BRIDGE TAP" CONNECTION

- Never untwist the twisted pairs of a CAT 5 cable beyond 12.7 mm (0.5 in.) from the point of termination. Untwisting the wires can decrease the cable's category performance rating and degrade system performance. See ANSI/TIA/EIA-568-B and CSA-T529 for additional information.
- Do not make sharp bends in CAT 5 cable. The bend radius for CAT 5 cable **shall not** be less than ten times the outside diameter of the cable. Bending the cable with a shorter bend radius can affect the electrical characteristics of the cable and degrade system performance. See ANSI/TIA/EIA-568-B and CSA-T529 for additional information.
- Do not pull a CAT 5 cable using a force greater than 110 Newtons (25 lb-force), or as suggested by the cable manufacturer. Pulling a cable with too much force can change the cable's electrical characteristics and degrade its performance. See ANSI/TIA/EIA-568-B and CSA-T529 for additional information.
- Do not over-tighten CAT 5 cable with cable ties or other supports. Over-tightening cable ties or other supports can change the electrical characteristics of the cable and degrade the system performance. Velcro-style cable ties are recommended. See ANSI/TIA/EIA-568-B and CSA-T529 for additional information.

9.9.6.6 TOPOLOGY

Computer network cabling **shall** utilize a "Star" topology, unless the specific design of the network calls for a different topology. Figure 9-12 shows a star topology example. See ANSI/TIA/EIA-568-B and CSA-T529 for additional information.

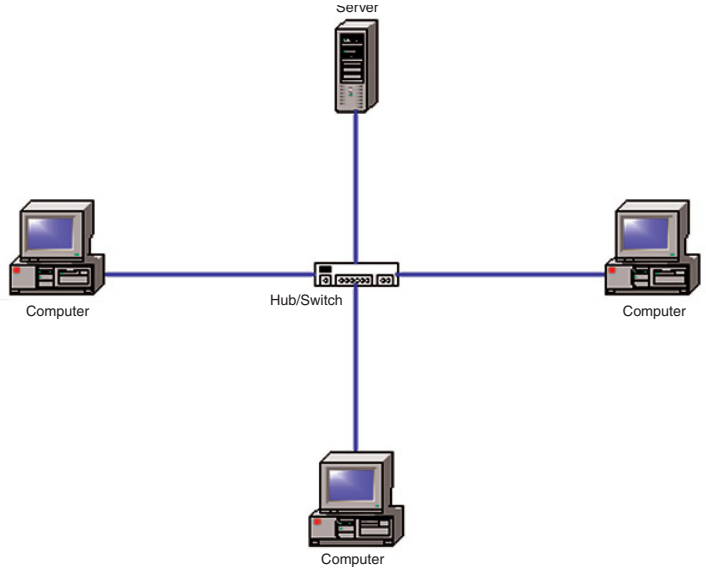


FIGURE 9-12 STAR TOPOLOGY

- CAT 5 segment lengths **shall not** exceed 100 m (328 ft.). This includes 90 m (295 ft.) of building cabling and up to 10 m (32.8 ft.) of equipment cords, cross-connects and patch cords. Of the 10 m (32.8 ft.) allowed for equipment cords, cross-connects and patch cords, a maximum of 3 m (9.8 ft.) should be used from the computer workstation to the information outlet. See ANSI/TIA/EIA-568-B and CSA-T529 for more details. Figure 9-13 shows the maximum cabling lengths between various network elements.

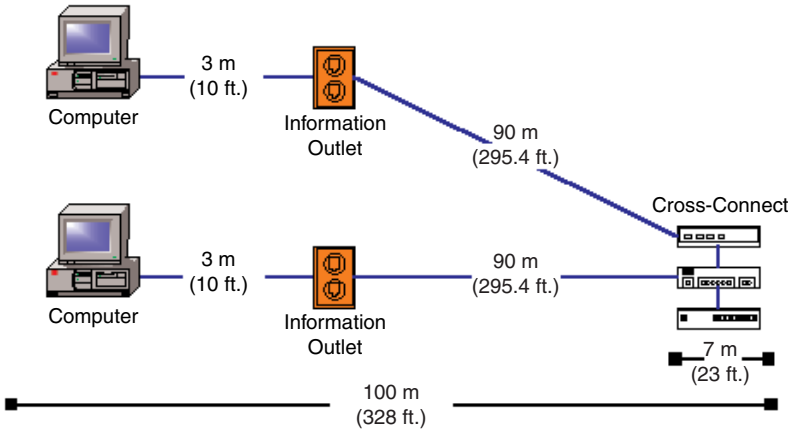


FIGURE 9-13 NETWORK SEGMENT LENGTHS LIMITATIONS

- For simplifying installation and reducing cable runs, a single CAT 5 cable may be run from the equipment room hub/switch to an additional hub/switch in the computer workstation area for distribution to the individual computers. This can reduce the number of cables required between the equipment room and the individual computers. Figure 9-14 shows an example of a single cable run. See ANSI/TIA/EIA- 569-B for additional information.

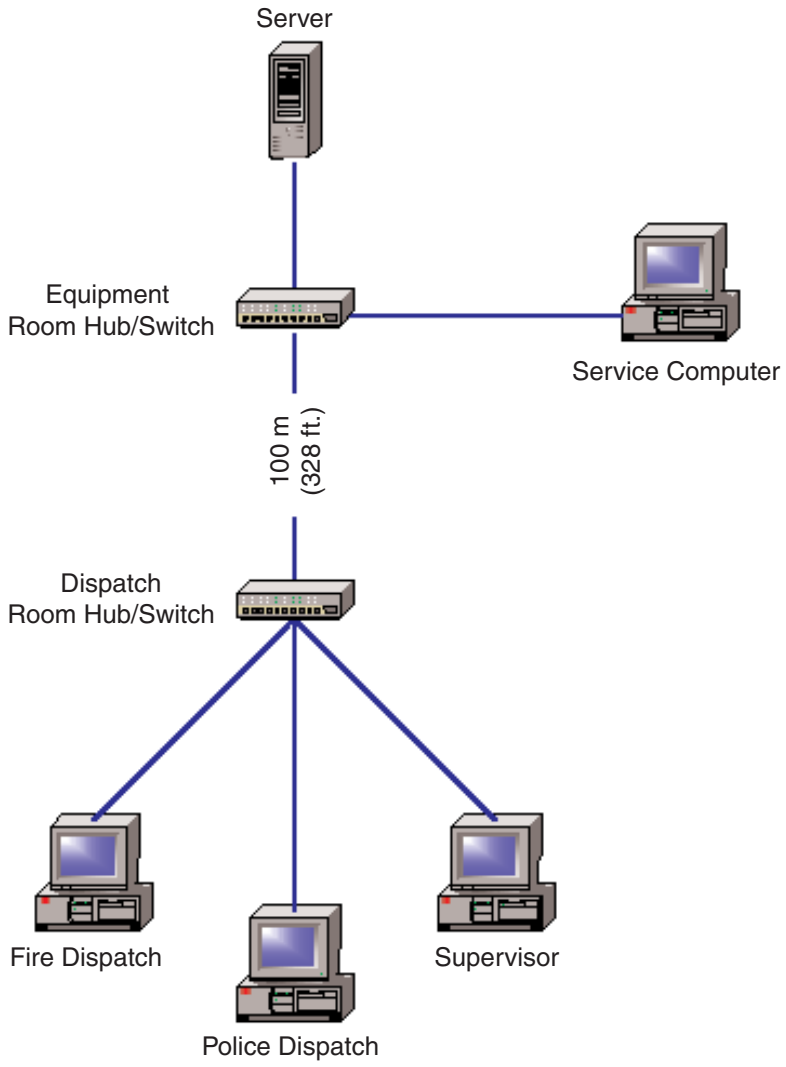


FIGURE 9-14 ADDITIONAL HUB/SWITCH USED IN SINGLE CABLE RUN

- If cable segments need to be extended beyond 100 m (328 ft.), an additional hub/switch may be installed. Each individual segment between hubs/switches **shall** not exceed 100 m (328 ft.). Figure 9-15 shows the cabling and network elements for distances exceeding 100 m (328 ft.). Note that no more than the one intermediate hub/switch **shall** be used. If the required distance is greater than as shown in Figure 9-15 on page 9-25, a specific cabling system **shall** be engineered. See ANSI/TIA/EIA- 569-B for additional information.

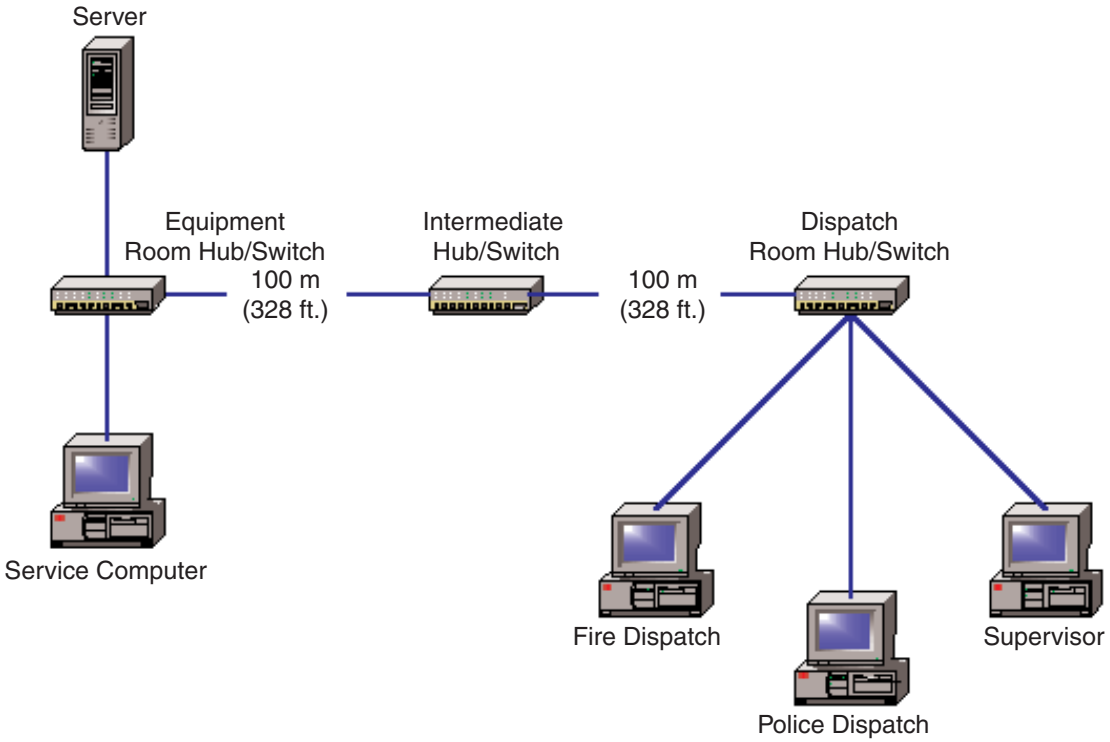


FIGURE 9-15 ADDITIONAL HUB/SWITCH USED FOR DISTANCES GREATER THAN 100 M

9.9.6.7 GROUNDING

Grounding **shall** comply with Chapter 5, "Internal Grounding (Earthing)," of this manual, NFPA 70-2005, Article 250; ANSI-J-STD-607-A-2002, and CSA-T527.

9.9.6.8 LABELING

Cables **shall** be labeled at both ends and at any pull boxes or junctions as described in "Cable Labeling" on page 9-30. See also ANSI/TIA/EIA-606-A and CSA-T528 for detailed labeling guidelines and suggestions.

9.9.6.9 TESTING NETWORK CABLING

Every effort should be made to ensure a quality installation of the computer network cabling system. Even the best installation effort cannot guarantee a properly working system. It is therefore required that a computer network cabling system be tested for proper performance.

The procedures and specifications in the TIA/EIA Telecommunications System Bulletin (TSB) 67 **shall** be used for this testing. TSB 67 has four primary parameters to test. Below is an overview of the four test parameters needed to assure a properly working system.

9.9.6.9.1 WIRE MAP

The wire map test is used to verify wire pair to pin termination at each end of the cable and check for installation connectivity errors. Each of the 8 conductors in the cable are tested for:

- Conductor continuity to the remote end of the cable
- Shorts between any two or more conductors in the cable
- Crossed pairs in the cable
- Reversed pairs in the cable
- Split pairs in the cable
- Any other wiring errors in the cable

9.9.6.9.2 LENGTH

The length test is used to determine the maximum physical length of the cable segments.

9.9.6.9.3 ATTENUATION

Attenuation is the measure of signal loss in the cable segment.

9.9.6.9.4 NEAR-END-CROSSTALK (NEXT) LOSS

NEXT loss is a measure of signal coupling from one wire pair to another within a single UTP cable segment.

9.9.7 OPTICAL FIBER CABLING

WARNING

Never look into an optical fiber cable. Optical fiber cables use invisible laser light that is dangerous and can cause damage to the eye.

Optical fiber cable are grouped into three general categories as described below. (See NFPA 70-2005, Article 770.9 for additional information.)

- Non-conductive - These cables contain no conductive materials.
- Conductive - These cables contain noncurrent-carrying conductive members, such as metallic strength members, metallic vapor barriers, and metallic armor or sheath.
- Composite - These cables contain optical fibers and current-carrying electrical conductors. These cable may also contain noncurrent-carrying conductive members, such as metallic strength members and metallic vapor barriers.

Observe the following general considerations for the installation of optical fiber cabling:

- Optical fiber cable installations **shall** conform to ANSI/TIA/EIA-568-B.
- Bend radius **shall not** be shorter than 10 times the diameter of the optical fiber cable, or as recommended by the cable manufacturer.

- Optical fiber cables **shall not** be installed in such a way that it prevents access to electrical equipment and removal of panels, including suspended ceiling panels. (See NFPA 70-2005, Article 770.21, and Figure 9-7 for additional information.)
- Optical fiber **shall** be installed in a neat and workmanlike manner. Cables **shall** be supported in such a manner that the optical fiber cable will not be damaged by normal use of the building. (See NFPA 70-2005, Article 770.24 for additional information.)
- Conductive optical fiber cables entering or leaving the building **shall** be have the noncurrent-carrying metallic members grounded as close as practical to the building entry. (See NFPA 70-2005, Article 770.93 and Chapter 5, "Internal Grounding (Earthing)," for additional information.)
- Optical fiber cables installed in plenums and other air-handling spaces **shall** be Plenum- rated cable and installed in accordance with NFPA 70-2005, Article 770. Plenum-rated optical fiber cable may be OFNP (Optical Fiber Non-conductive Plenum) or OFCP (Optical Fiber Conductive Plenum).
- Optical fiber cables installed in vertical runs penetrating more than one floor, or cables installed in vertical runs in a shaft **shall** be Riser or Plenum-rated cable. Riser rated optical fiber cable may be OFNR (Optical Fiber Non-conductive Riser) or OFCR (Optical Fiber Conductive Riser). (See NFPA 70-2005, Article 770 for additional information.)
- Non-conductive optical fiber cable **shall** be permitted to occupy the same cable runway or raceway with conductors for electric light, power, Class 1, nonpower-limited fire alarm, or medium power network-powered broadband communications circuits operating at 600 Volts or less. (See NFPA 70-2005, Article 770.133 for additional information.)
- Conductive optical fiber cable **shall not** be permitted to occupy the same cable runway or raceway with conductors for electric light, power, Class 1, nonpower-limited fire alarm, or medium power network-powered broadband communications circuits. (See NFPA 70-2005, Article 770.133 for additional information.)
- Composite optical fiber cables containing only current-carrying conductors for electric light, power, Class 1 circuits rated 600 Volts or less **shall** be permitted to occupy the same cabinet, cable runway, outlet box, panel, raceway, or other termination enclosure with conductors for electric light, power, or Class 1 circuits operating at 600 Volts or less. (See NFPA 70-2005, Article 770.133 for additional information.)
- Non-conductive optical fiber cables **shall not** occupy the same cabinet, outlet box, panel, or similar enclosure housing the electrical terminations of an electric light, power, Class 1, nonpower-limited fire alarm, or medium power network-powered broadband communications circuit, unless the optical fiber cable is functionally associated with the other cables. (See NFPA 70-2005, Article 770.133 for additional information.)
- Where exposed to contact with electric light or power conductors, the non-current-carrying metallic members of optical fiber cables entering buildings **shall** be grounded as close to the point of entrance as practical or **shall** be interrupted as close to the point of entrance as practical by an insulating joint or equivalent device (NFPA 70-2005, Article 770.93).
- Conductive and non-conductive optical fiber cable **shall** be permitted in the same cable runway, enclosure, or raceway with conductors of Class 2 and Class 3 remote-control, signaling, and power-limited. circuits in compliance with NFPA 70-2005, Article 725; power-limited fire alarm systems in compliance with NFPA 70-2005, Article 760; communications circuits in compliance with NFPA 70-2005, Article 800; community antenna television and radio distribution systems in compliance with NFPA 70-2005, Article 820; and low-power network-powered broadband communications circuits in compliance with NFPA 70-2005, Article 830. (NFPA 70-2005, Article 770.133).
- Where fiber optic cabling is used, the fiber optic cable **shall** be labeled to distinguish it from electrical signal cabling. (See Figure 9-16.)

COLORED ARMOR

LABEL

FIGURE 9-16 FIBER OPTIC CABLE IDENTIFICATION

9.9.8 RF CABLING

RF cabling typically consists of 6.35 mm (0.25 in.) or 12.5 mm (0.5 in.) coaxial cables of foam filled or superflexible construction.

RF cabling **shall not** be run nearer than 50.8 mm (2 in.) to conductors of other wiring systems (NFPA 70-2005, Articles 810.18, 810.70, and 820.133). Bend radius considerations **shall** be observed as specified below, or as otherwise specified by the cable manufacturer.

Minimum bend radius for superflexible cable sizes:

- 6.35 mm (0.25 in.) diameter cable: 25.5 mm(1 in.) bend radius
- 12.5 mm (0.5 in.) diameter cable: 31.7 mm (1.25 in.) bend radius

Minimum bend radius for foam-filled cable sizes:

- 12.5 mm (0.5 in.) diameter cable: 127 mm (5 in.) bend radius
- 22.2 mm (0.875 in.) diameter cable: 254 mm (10 in.) bend radius
- 31.7 mm (1.25 in.) diameter cable: 381 mm (15 in.) bend radius
- 41.3 mm (1.625 in.) diameter cable: 508 mm (20 in.) bend radius

9.9.9 CABLING IN TELEPHONE WIRING ENVIRONMENTS

NOTE: The following considerations apply only in cases where customer work must meet specifications stipulated by a telephone utility. If no special stipulations are stated by the telephone company, best commercial practices such as Telcordia specifications may be used for telephone company cabling within the communication site. When installing cabling that connects with telephone company assets or a demarcation point, inquire about any lacing requirements before work is performed.

9.9.9.1 ELECTRICAL INTERFACE REQUIREMENTS

Connection to telephone company assets may require the use of surge suppression for customer signal circuits that interface to telephone company circuits. Inquire through the telephone company regarding these requirements before connecting to telephone company circuits.

9.9.9.2 CABLING LACING REQUIREMENTS

When installing a system for telephone company or possibly other utility companies, special cabling methods **may** be required. Observe the following considerations for the installation of telephone company cabling:

- Lacing, rather than nylon cable ties, **shall** be used as the preferred means of cable attachment to cable tray, to eliminate the possibility of sharp edges found on cut cable ties.
- The lacing method specified by the telephone company **shall** be used. Typical lacing is shown in Figure 9-17.

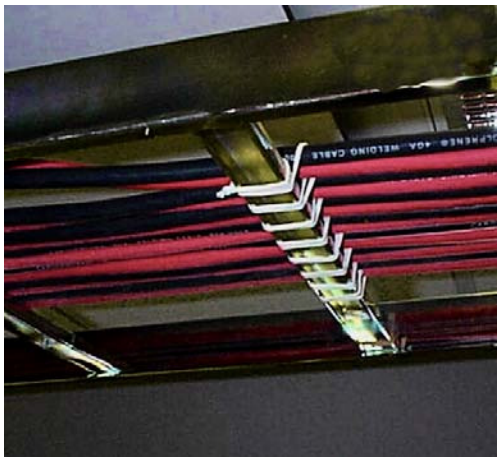


FIGURE 9-17 TELEPHONE COMPANY LACING METHODS

- Lacing is typically 4- or 9-ply waxed polyester twine.
- Lacing of horizontal cables in cable trays should be performed every 914 mm (3 ft.).
- Lacing of vertical cables to a cable ladder should be performed at every rung of the cable ladder. Any cable hanging between horizontal/vertical runways and racks cannot be unsupported for more than 610 mm (24 in.).

9.9.10 DISTRIBUTION FRAME CONFIGURATIONS

A distribution frame (Figure 9-18 on page 9-30) provides a centralized cross-connection point for audio, data, and alarm and control wiring between different pieces of equipment at a site and between the site and external lines. Distribution frames **shall** be implemented using one of the following methods:

- Distribution punch blocks affixed to a plywood panel that is mounted on a wall or a rack.
- Distribution punch blocks mounted on open-rack frames available from various manufacturers. These frames can be anchored to the floor; they save wall space at the cost of floor space.
- Typically, a distributed (as opposed to centralized) method is used. Pre-wired cross-connect panels (each 1 rack unit in height) distribute connections on a rack-by-rack basis. Typically, remote sites require one panel and the prime site is equipped with one to three panels, depending on the application.

- Cables should be dressed up into the cable runway or down into the under-floor raceway as dictated by the site design.

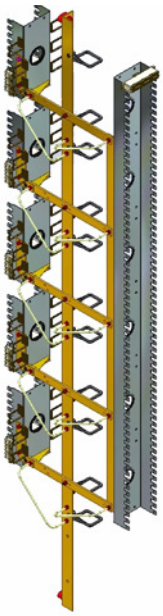


FIGURE 9-18 TYPICAL DISTRIBUTION FRAME

9.9.11 DISTRIBUTION FRAME CROSS-CONNECT WIRING

- Cross-connect wires **shall** be AWG #22 - #24 (0.644 mm - 0.511 mm) plastic-insulated **solid** copper wire. Stranded wire **shall not** be used.
- Individual wires **shall** enter the punch terminal from the top so that the wire tail points down after punch-down. (CAT3, 4, 5, or 6 data wiring **shall** enter punch terminals from the middle such that one wire points up while the other points down. In this manner, the cable twist that maintains the cable impedance stays intact.)
- The wiring **shall** dress down the source block column, across the bottom of the frame, and up the destination block column. Approximately 50.8 mm (2 in.) of service loop at each end of the punched down wire **shall** be allowed.
- Wiring **shall** be properly secured using industry-standard methods.

9.9.12 CABLE LABELING

Cabling **shall** be identified with a standardized, double-ended system to facilitate cable and equipment connection identification. (See ANSI/TIA/EIA-606 for additional information.) Observe the following when devising a cable labeling system:

- Labeling **shall** identify the direction along the cable where terminating equipment is located.
- Labeling **shall** indicate the destination ends of the cable, including equipment name and connector reference designator or name. This applies to connectorized, lugged, or punched down cable terminations regardless of the application (RF, audio, or control).

- Labeling **shall** be imprinted on white opaque material (preferably plastic or plasticized paper) using indelible black ink.
- Label placement **shall** be between 101 to 152 mm (4 to 6 in.) from each end of the cable (or the most logical point that would allow the label to be easily read).
- Labeling should wrap entirely around the cable. It should be secure enough to assure label retention if cable is to be pulled through conduit.
- Information printed on each label should be brief but clearly understandable. Use industry-standard abbreviations and acronyms to conserve label space.

FIGURE 9-19 EXAMPLE OF CABLE LABELING

9.10 ELECTROSTATIC DISCHARGE CONSIDERATIONS

Installation and repair of certain equipment will require removal and replacement of Field Replaceable Units (FRUs) within the equipment for purposes of setting configurations or installing FRUs specific to site applications. Whenever equipment must be opened, electrostatic discharge (ESD) precautions **shall** be adhered to. In general, the following requirements **shall** be met:

- An ESD-protected work area **shall** be present.
- An ESD wriststrap **shall** be worn when handling ESD-sensitive modules.
- ESD-protected packaging **shall** be available for containing modules removed from equipment.

All precautions specifically stated for the equipment being worked on **shall** be adhered to in accordance with the respective documentation for the equipment.

It is recommended that replacement FRUs be stored in their anti-static packaging, in an anti-static cabinet or enclosure to ensure that they are protected from ESD until they are needed for equipment repair.

See Appendix B for general ESD information.

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