Los Angeles
World Airports

INFORMATION TECHNOLOGY INFRASTRUCTURE STANDARDS OF PRACTICE

VOLUME 2 OF 3
BACKBONE DISTRIBUTION
HORIZONTAL DISTRIBUTION
COMMON ELEMENTS

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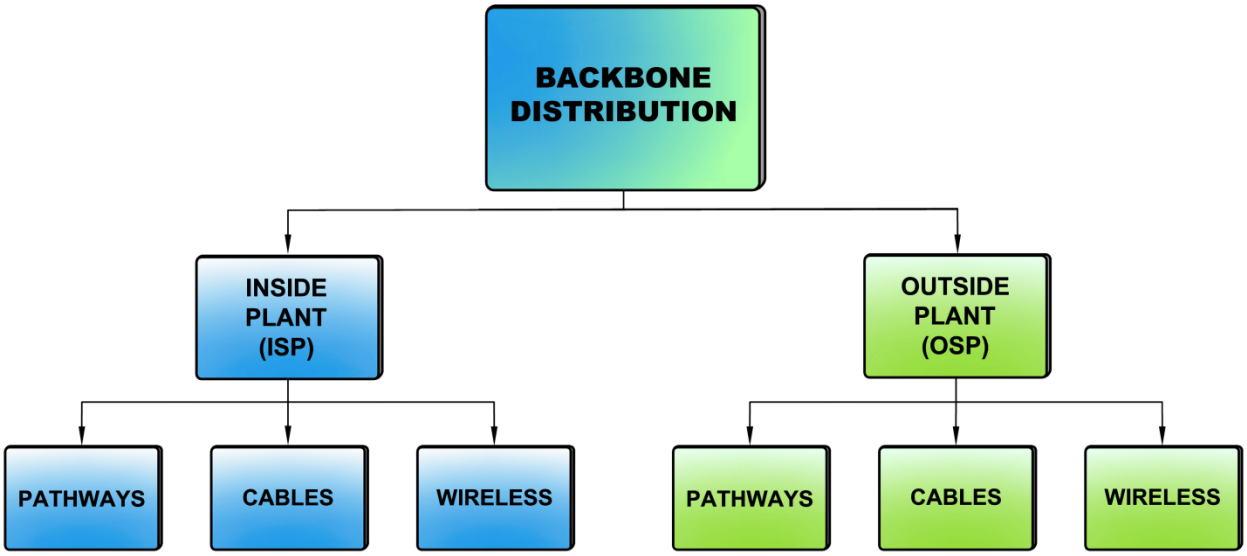
1. BACKBONE DISTRIBUTION (BD)

1.1. BD > GENERAL

1.1.1. Backbone Distribution (BD) includes Inside Plant (ISP) and Outside Plant (OSP) that connect two or more buildings together or connect the MPOE to each local IT Room. The following components are part of a Backbone Distribution system.



Major components of Backbone Distribution – To connect buildings or terminals.

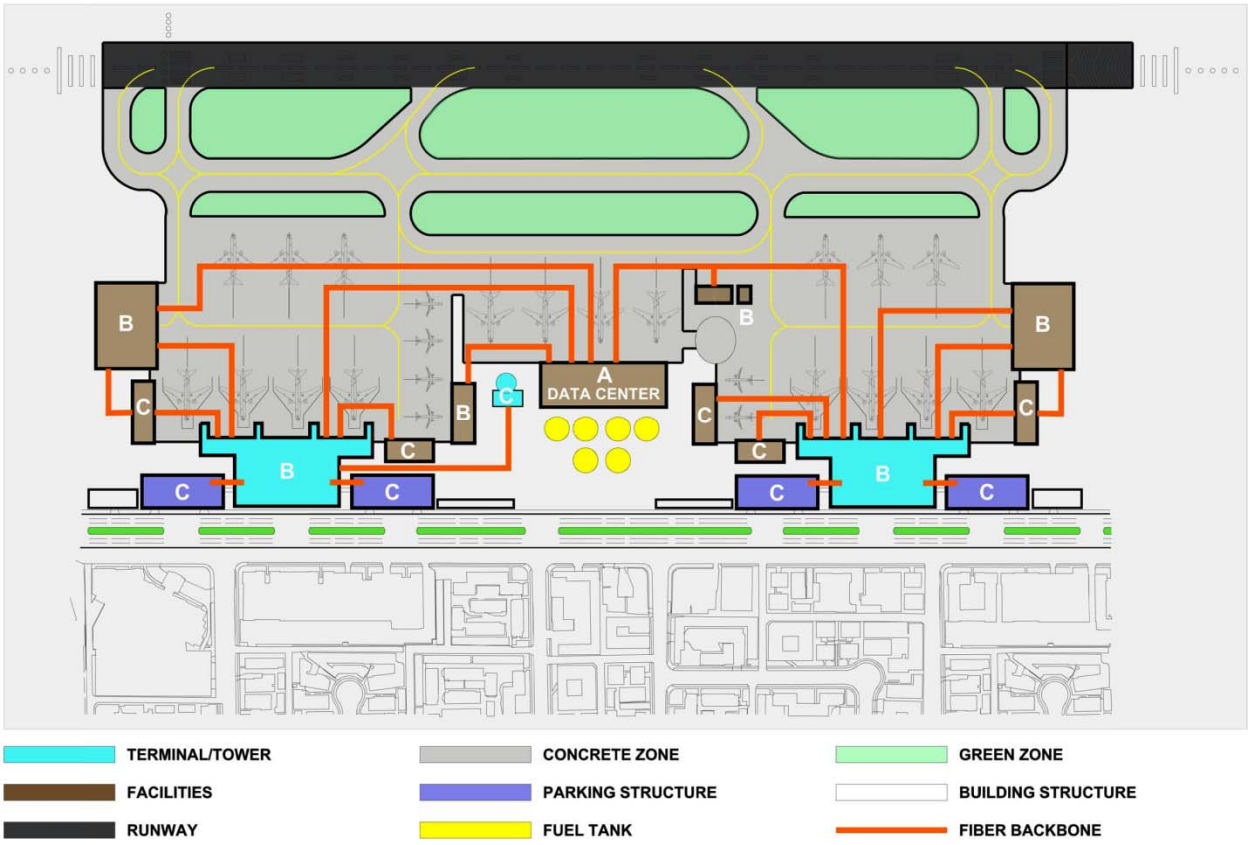
1.2. BD > TOPOLOGY

1.2.1. BD has a fiber and copper topology that is a method of connecting facilities. LAWA uses two types of topology, hierarchical star and physical ring/logical star.

1.2.2. Hierarchical star means that there are multiple levels in the BD. Building A can feed building B and then building B in turn feeds building C. This is a two level hierarchical star. LAWA does not exceed more than two levels.

1.2.3. Hierarchical star topology can have single or redundant pathways.

1.2.4. The diagram below shows a data center in the middle of the site plan with orange lines representing BD going to various buildings and in some cases extending to other buildings.



Two-level Hierarchical Star Topology

1.2.5. For operational mission-critical facilities, LAWA requires a separate, redundant, geographically diverse hierarchical topology to be installed.

1.2.6. LAWA operational mission-critical facilities include passenger terminals, control centers, office buildings, and other facilities. See LAWA for details.

1.2.7. Hierarchical Star topologies has advantages and disadvantages.

1.2.8. Advantages of a Hierarchical Star include:

- Network efficiency is better due to centralized monitor and control.
- Data transmission performance is improved because signals are point-to-point and going around a ring.
- Other network nodes are not affected when adding or removing equipment or when there is peripheral equipment failure.

1.2.9. Disadvantages of a Hierarchical Star include:

- Centralized monitor and control requires numerous backup systems and utilities to help prevent the entire network from failing.
- System performance is dependent upon the speed and configuration of the central network components.

- Equipment costs are increase due to the number of core, distribution, and access switches and their redundant switches required.

1.2.10. For existing facilities, when there is one and only one pathway available and there is a need to get from one location to multiple locations, LAWA uses a physical ring/logical star topology. There are advantages and disadvantages.

1.2.11. Physical ring/logical star topology means that the cable is physically connected in a loop from building to building around a ring. Each individual building is connected point-to-point back to the data center because specific pairs are split off and terminated for each particular building.

1.2.12. The diagram below shows the buffer tubes of a 216 strand fiber that is installed in the single pathway between each building with 24-strands split off clockwise and counter-clockwise for each building served.

1.2.13. Advantages of the Physical Ring/Logical Star topology are:

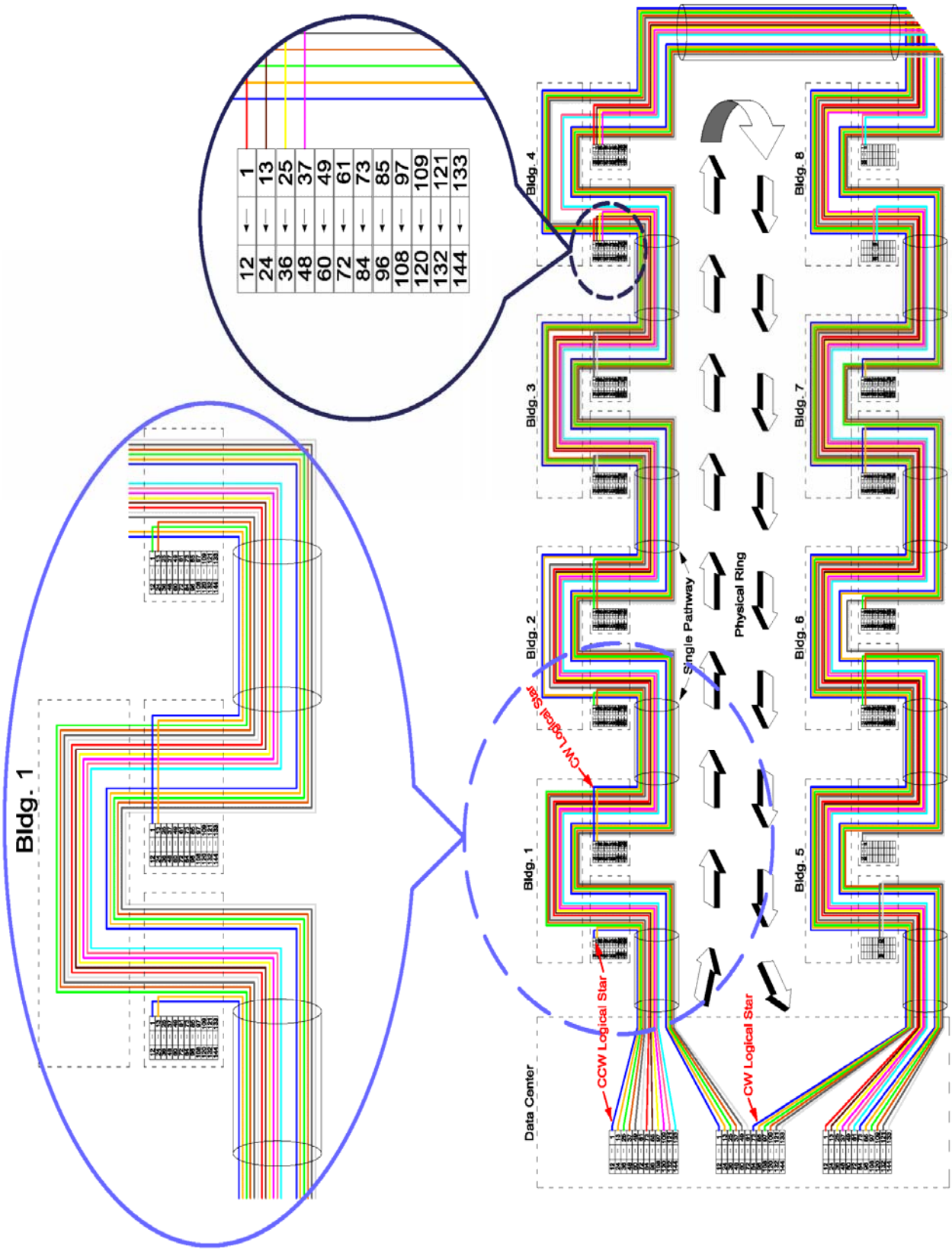
- Only one pathway is required from the data center to the first and last building and between each building
- Budget savings due to fewer pathways to install
- Point-to-point connectivity to multiple locations via one pathway
- Some geographic diversity because there is a clockwise and a counter-clockwise pathway from each building to the data center

1.2.14. Disadvantages of the Physical Ring/Logical Star topology are:

- On long runs, there are too many fusion splices in each building to provide for all of the fiber strands that continue through the buildings
- Larger patch panels or separate junction boxes are be required for splicing
- If the cable segment needs to be cut at any place around the ring to accommodate a future renovation project in any of the buildings, then all buildings are affected. This results in long protracted fiber cutovers that are costly and time-consuming.

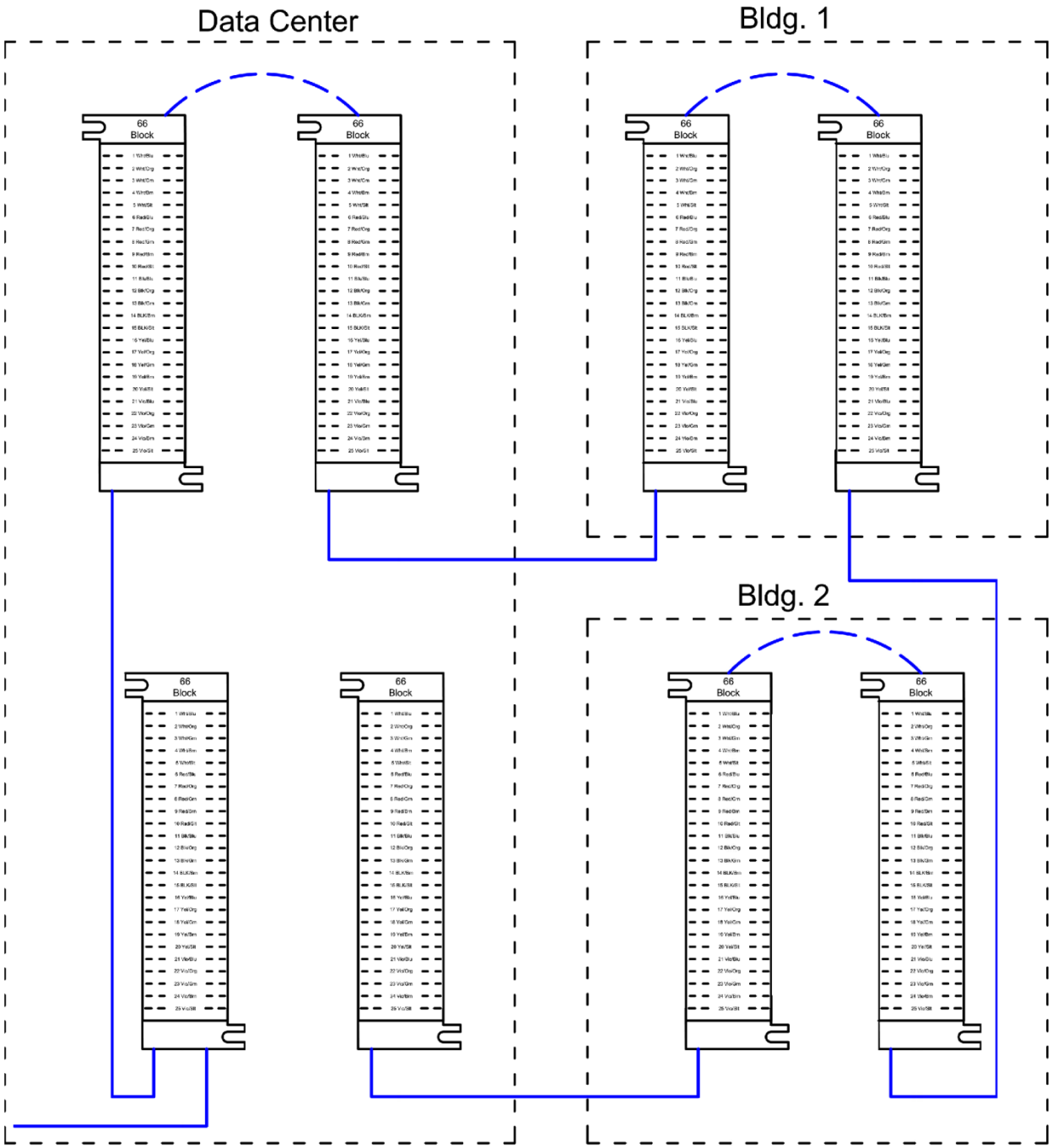
1.2.15. The diagram on the next page shows a 216 strand fiber optic Physical Ring/Logical Star layout with fiber segments connecting between each building. The 216-strand fiber cable segments enter each building to drop off and terminate 2 fiber buffer tubes or 24 fiber strands. The 216-strand fiber cable segments then exit each building after dropping off another 2 fiber buffer tubes or 24 fiber strands.

1.2.16. The between-building segments create a ring around all facilities. All other buffer tubes not terminated are fusion-spliced to their counterparts. This is how the point-to-point connection is created. Each building has a dedicated clockwise path and another dedicated counter-clockwise path to the data center.



Physical Ring/Logical Star - Fiber buffer tubes are shown dropping off at each facility.

1.2.17. The diagram below shows a similar layout for a copper backbone Physical Ring/Logical Star cable that is restricted to a single pathway to three buildings but must provide the point-to-point connectivity of a star topology.



Physical Ring/Logical Star - A Copper cable is shown dropping off at each facility.

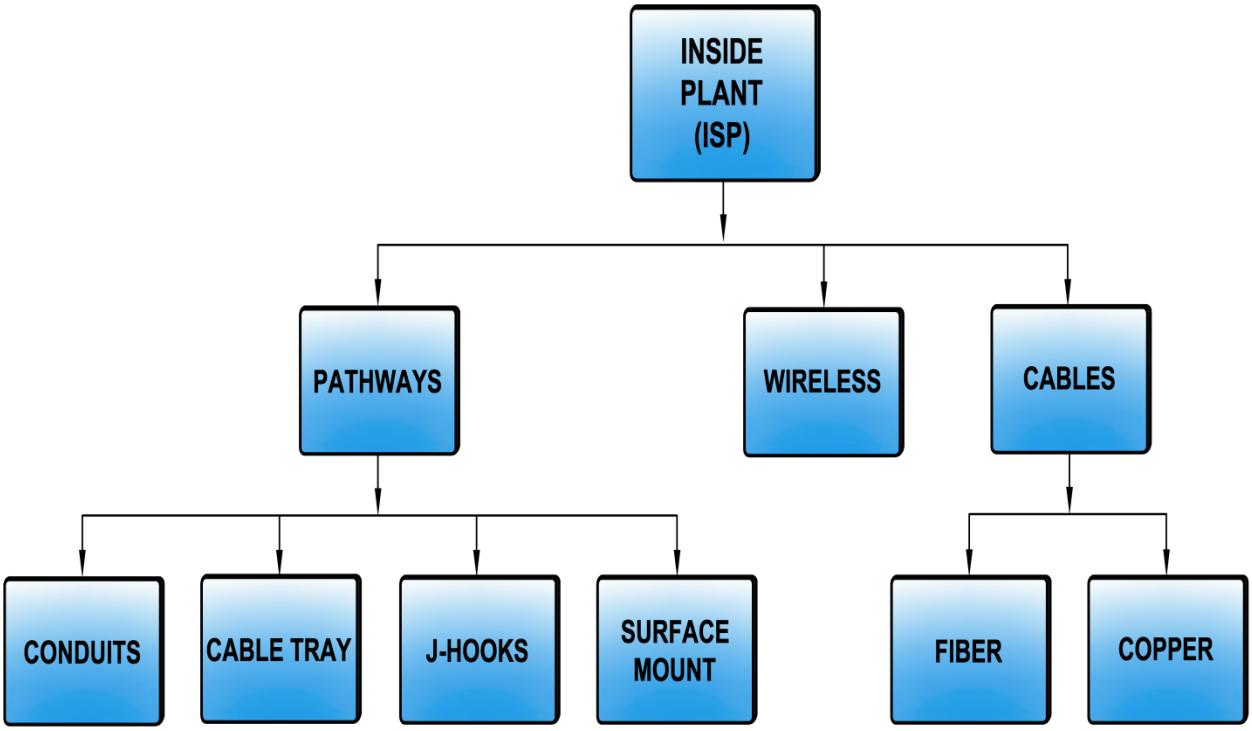
1.3. BD > INSIDE PLANT (ISP)

1.3.1. Inside plant is the collection of all indoor pathways, cables, and wireless, that is used to transport voice, video, and data.

1.3.2. ISP pathways include underfloor, in-floor, above ceiling, in-wall, surface-mount, pole-mount, and wireless.

1.3.3. ISP cables include optical fiber, CAT 6 and 6A horizontal, coax, and low-voltage instrumentation-type conductors.

1.3.4. ISP wireless is typically between within facilities but can purposely extend beyond building perimeter walls to serve adjacent areas.



Inside Plant basic components flowchart.

1.4. BD > ISP > PATHWAYS > CONDUIT

1.4.1. A minimum of two (2) 4-inch point-to-point Electrical Metallic Tubing (EMT) conduits shall connect the MPOE to each individual IT Room.

1.4.2. EMT conduit shall be used for indoor pathways except where Galvanized Rigid Conduit (GRC) or cable tray or other pathway is required.

1.4.3. Flexible or Sealtite conduit can be used for electrical extensions, field equipment pathway whips, crossing building expansion joints, and under access floors.

1.4.4. All conduits shall be grounded as per National Electric code (NEC) requirements.

1.4.5. All indoor communications conduits installed in new facilities shall be plated blue for easy identification.

1.4.6. IT conduits shall be separated from fluorescent light fixtures and other utilities by six a minimum of (6) inches.

1.4.7. Surface-mount and pole-mount raceways approved by LAWA, are acceptable for office furniture.

1.4.8. Conduits shall be installed neatly and professionally as shown in the picture below.

1.4.9. Conduits shall be labeled on both ends as to the origin and destination. See the Labeling section for details.

1.4.10. Surface-mount and pole-mount raceways are acceptable for furniture.

1.4.11. All conduit segments between two devices shall be numbered. Conduit numbers shall be placed on the label and on a conduit schedule spreadsheet. See Label Section for details.

1.4.12. A conduit schedule spreadsheet shall be added on the drawings as part of the as-built documentation package.

A neat, professional, blue-plated conduit installation is shown.

A neat and professional conduit installation.

1.5. BD > ISP > PATHWAYS > CONDUIT > BEND RADII

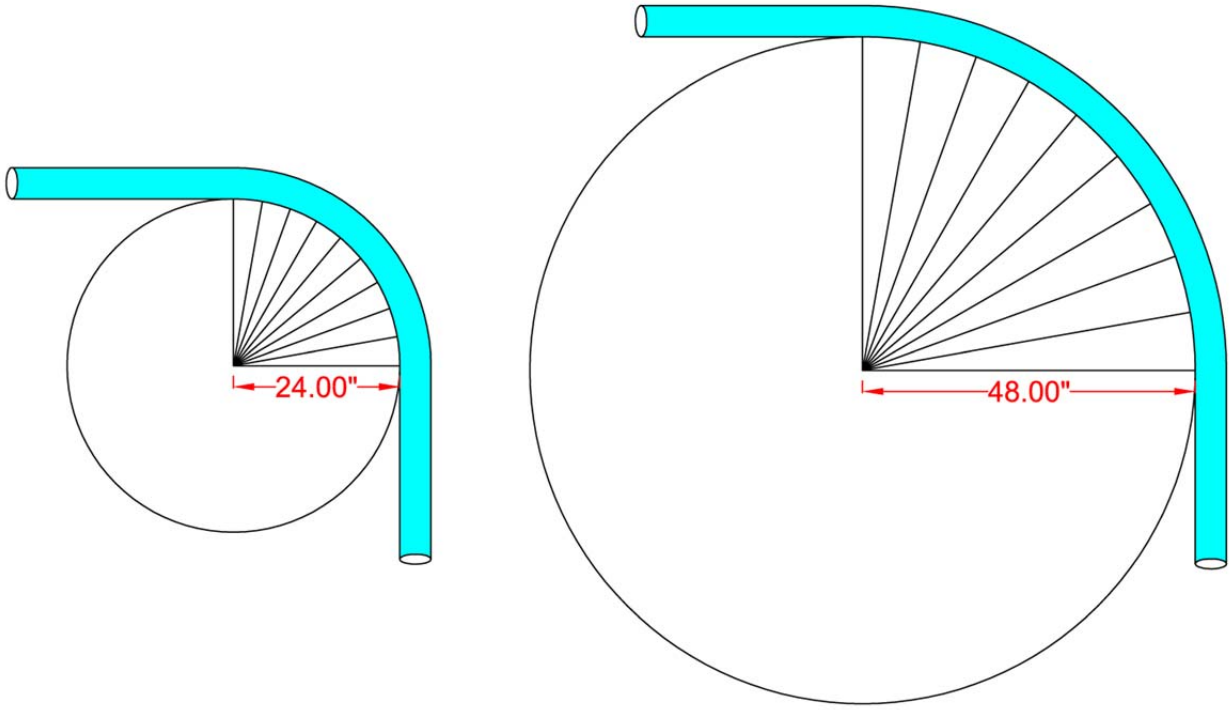
1.5.1. For conduit bend radii for backbone cables, LAWA errs on the side of safety by following TIA/EIA – 568-1 standard Section 10.3.1 which states "…*not less than 20 times the cable outside diameter when the cable is under a tensile load up to the rating of the cable, usually 2670 N (600lbf)."*

1.5.2. The current O.D. for fiber cables is 1-inch. 20x 1" = 20-inches. Since a 20-inch conduit radius is not standard, it is rounded up to 24-inches.

1.5.3. Therefore, the bend radius for a 2-inch conduit shall be a minimum of 24-inches.

1.5.4. The bend radius for a 4-inch conduit shall be a minimum of 48-inches.

1.5.5. The minimum bend radius for conduit that carries greater than 300-pair copper backbone cable is determined by the Service Provider. Consult specific Service Providers for required bend radii for their cables.



Bend radii requirements for fiber and copper cables.

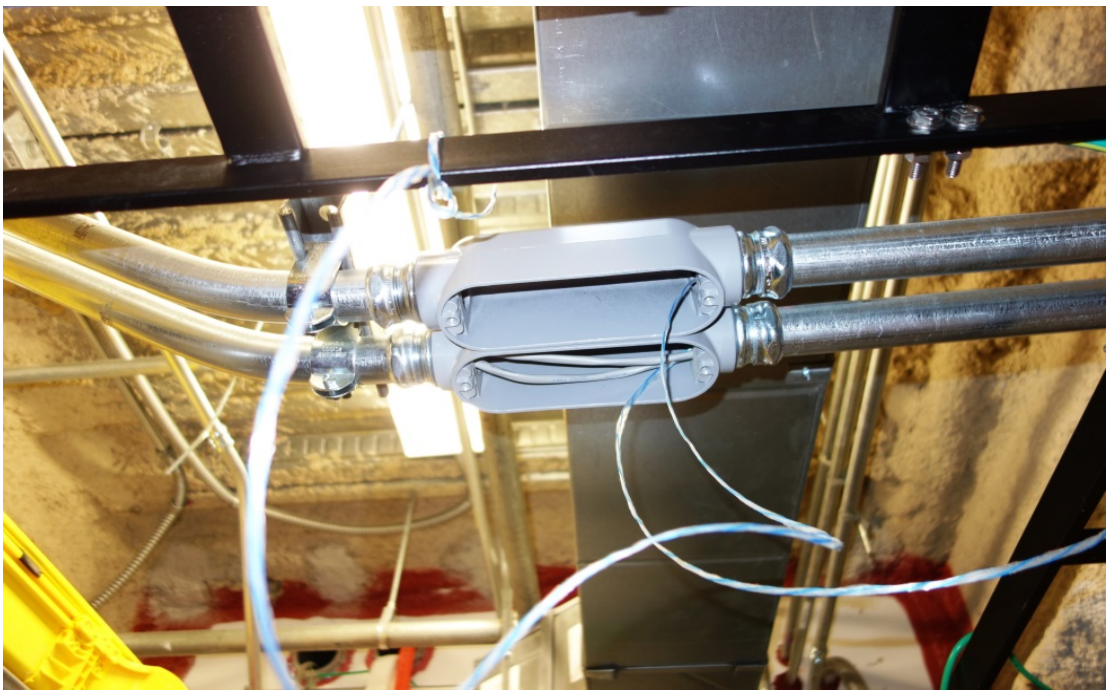
1.6. BD > ISP > PATHWAYS > CONDUIT > BODIES/CONDULETS

1.6.1. Conduit bodies/condulets are allowed for IT copper cables.

Conduit bodies/condulets used for copper cables.

1.6.2. Conduit bodies/condulets are not allowed for fiber cables.

1.6.3. Empty conduit bodies/condulets shall have pull strings and covers. Pull strings shall be tied off at each end. Covers shall be screwed in place.



Conduit bodies/condulets shown with pull strings.

1.7. BD > ISP > PATHWAYS > CONDUIT > BUSHINGS

1.7.1. All conduits and connectors shall have protective bushings.

1.7.2. Metal bushings shall be grounded as per the NEC.

Metal conduit bushings shown with grounding wires.

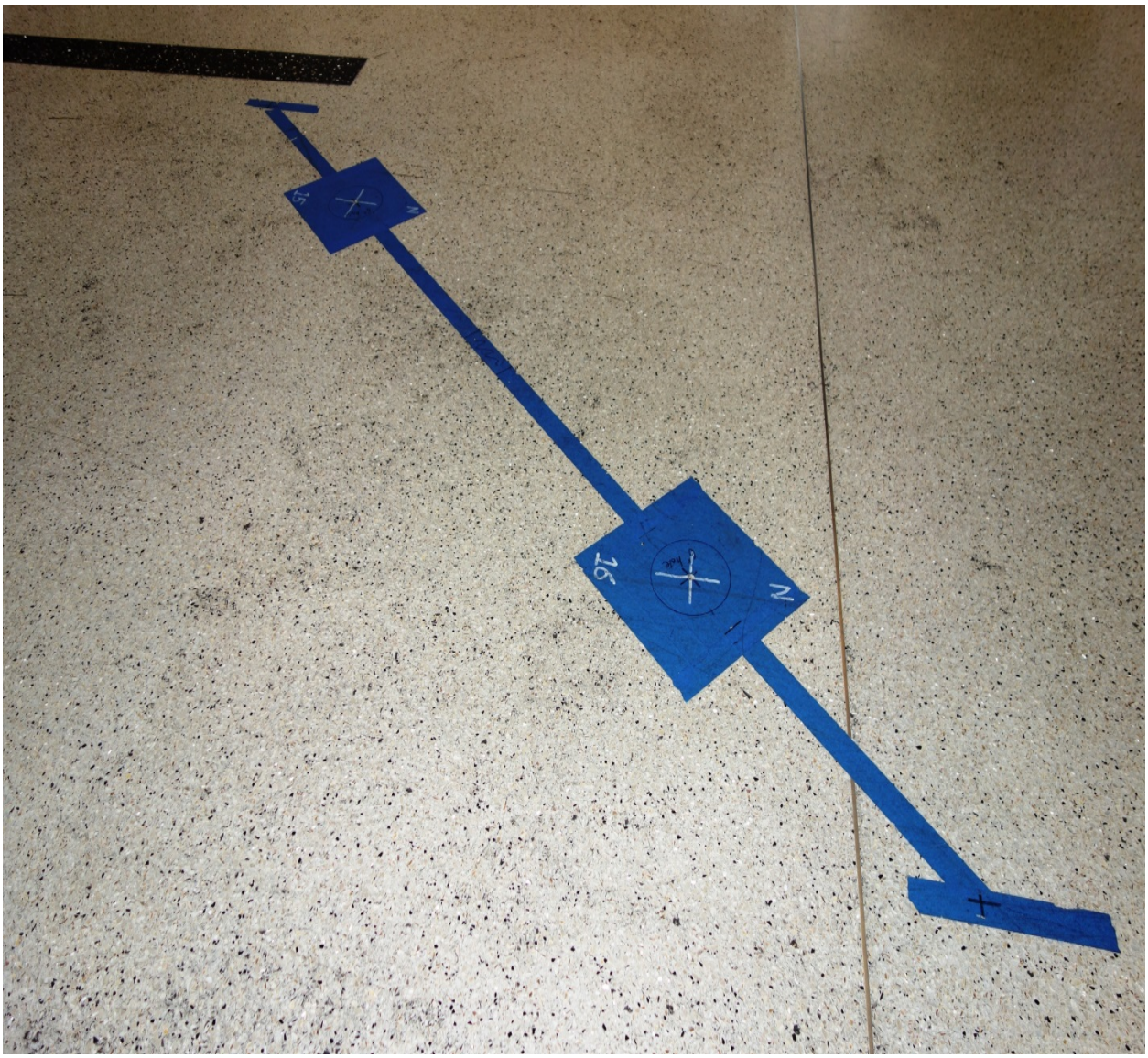
A neat professionally-installed and labeled horizontal conduit bank with bushings is shown.

Legacy conduits are missing bushings.

1.8. BD > ISP > PATHWAYS > CONDUIT > CORING

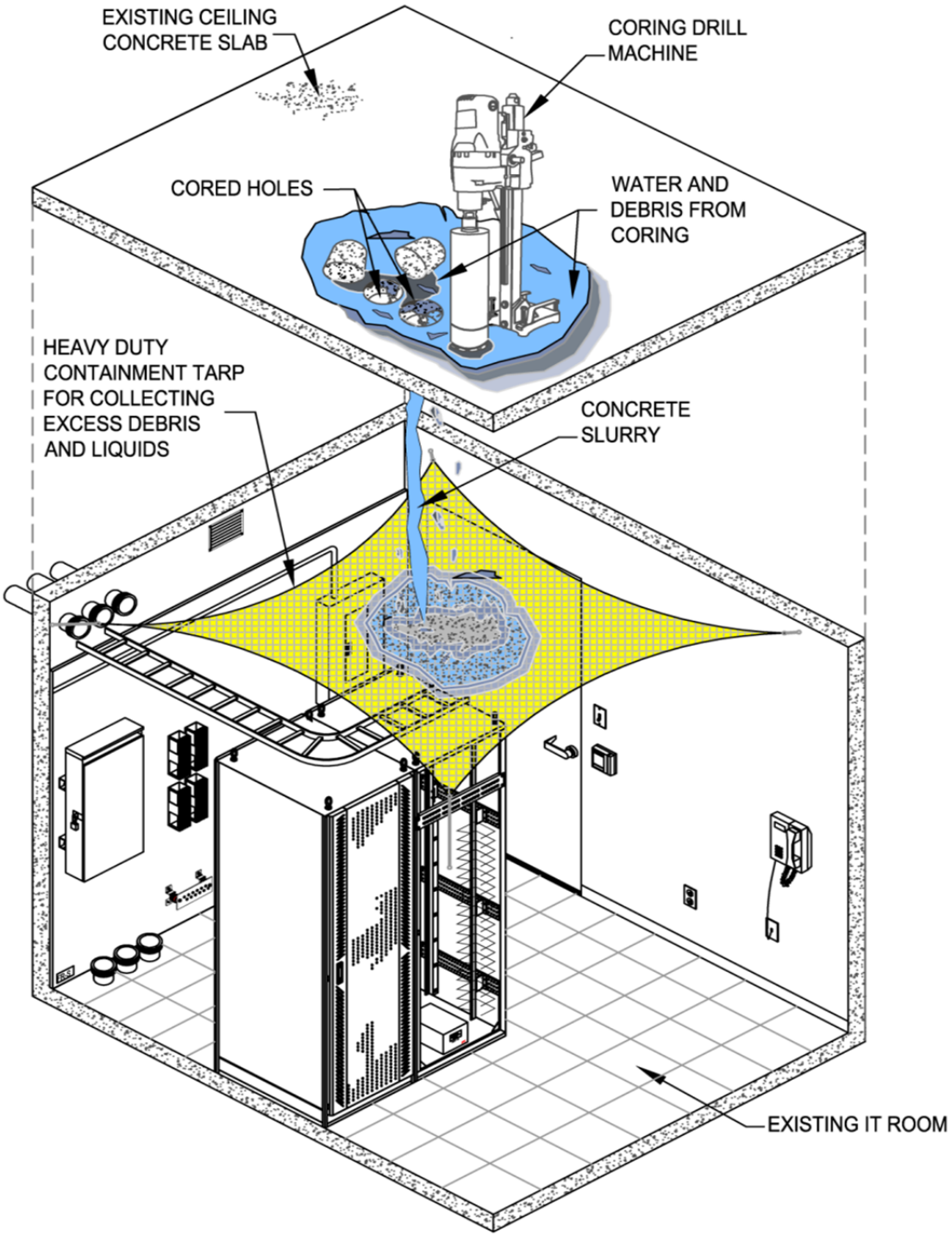
1.8.1. Permits for core drilling through concrete floors for conduit pathways shall be applied for through the LAWA Utility Shutdown Request (USR) process. Approval may be issued by permit upon review and comment by LAWA Divisions, provided that structural integrity and other utilities are not compromised.

1.8.2. The concrete pathway shall be X-rayed prior to drilling. X-ray results shall be submitted to LAWA for review and approval.



Proposed coring locations are shown laid out prior to X-Ray.

1.8.3. The concrete slurry from the drilling shall not be allowed to cause damage or stain anything either above or below coring operation. Provisions shall be made to protect the environment with plastic tarps and dry rags to contain the slurry.



Containment tarp in the ceiling below to catch concrete slurry.

1.8.4. All slurry shall be cleaned up and the environment returned to the pre-coring conditions.

1.8.5. A wet/dry vacuum shall be used continuously during coring operations.

Concrete coring machine - Courtesy: www.CoolMan.com/my.

1.8.6. Projects and/or contractors that allow concrete slurry to contaminate and/or damage equipment shall expeditiously replace the contaminated equipment at no charge to LAWA IT.

1.8.7. All core-drilled openings shall be properly firestopped per City of Los Angeles building requirements.

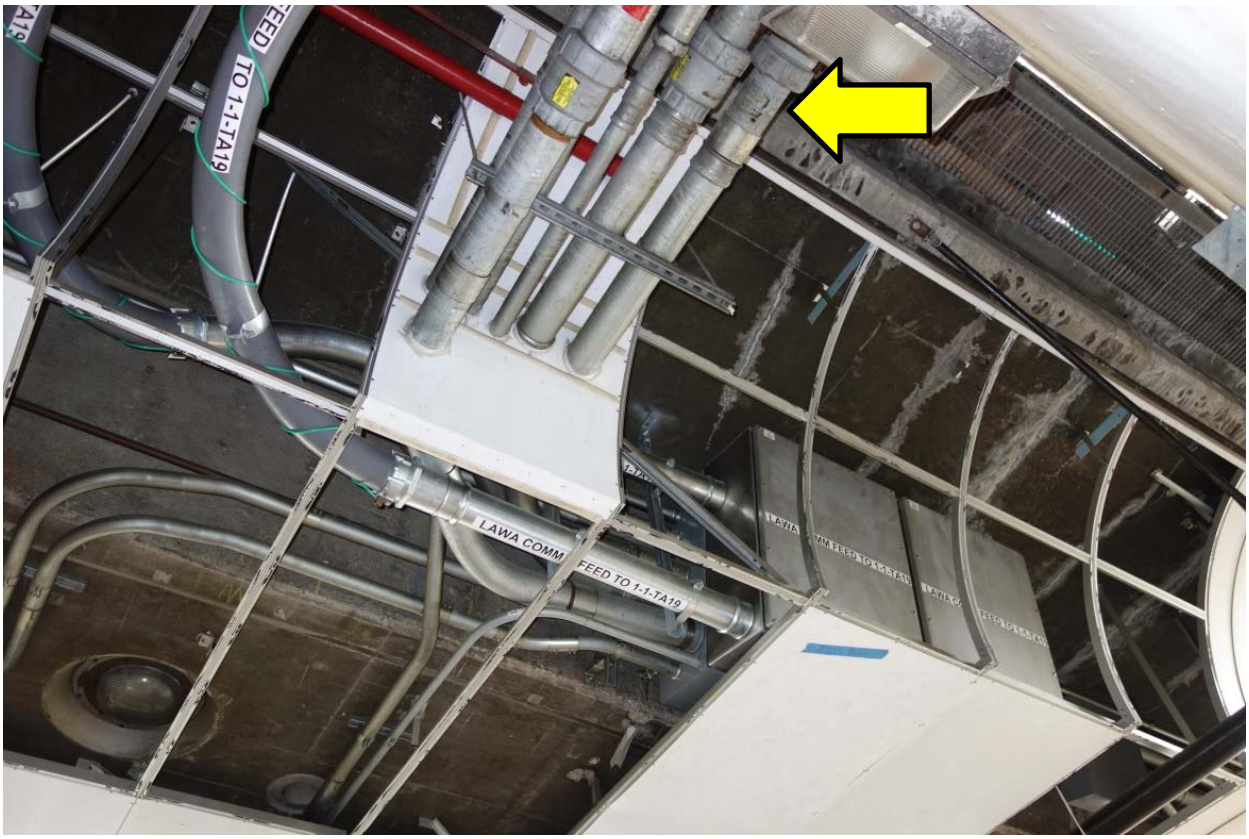
1.9. BD > ISP > PATHWAYS > CONDUIT > EXPANSION JOINTS

1.9.1. All conduits crossing building and roadway joints shall have conduit expansion joints installed.

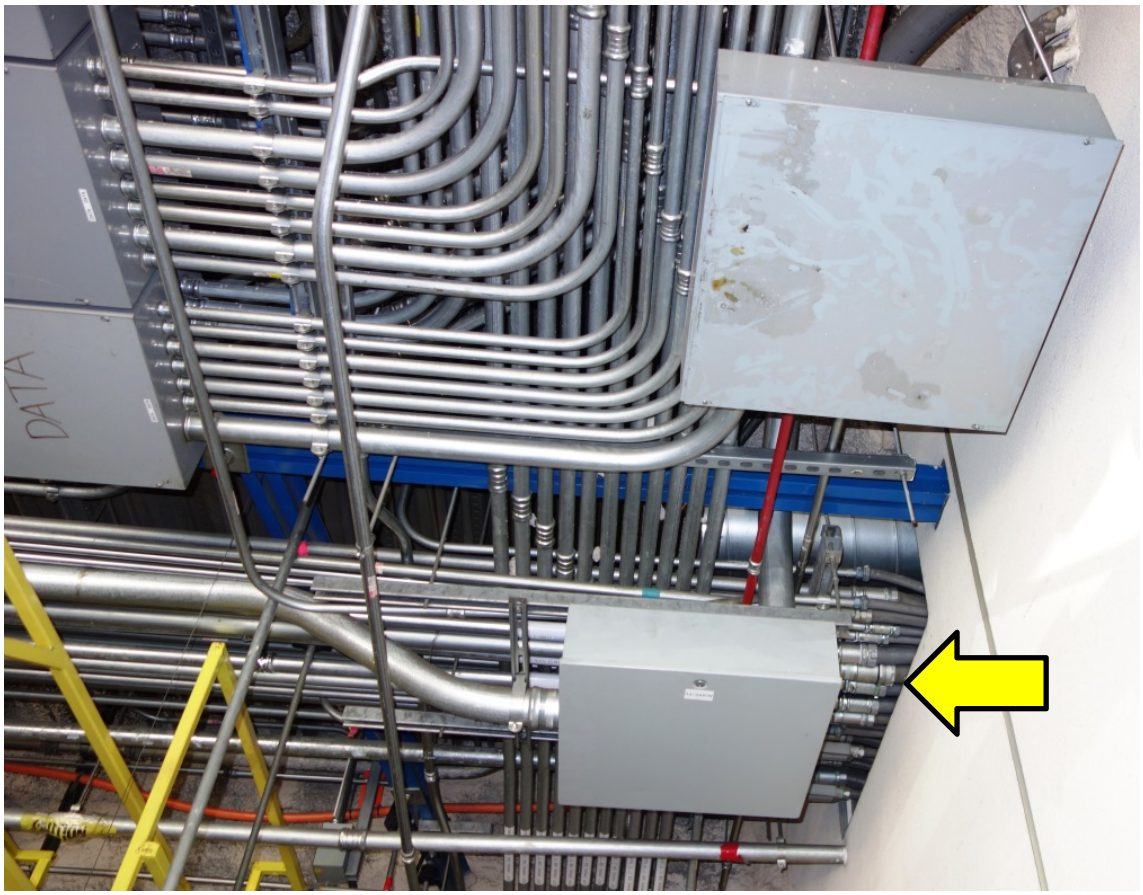
1.9.2. Liquid-Tight Flexible Metal Conduit (LFMC), Liquid-Tight Flexible Steel Conduit (LFMC), or expansion couplings are allowed if approved by the AHJ.

1.9.3. Conduit expansion joints with internal grounding or bonding straps for external grounding shall be used as required.

Conduit expansion joint with internal grounding shown. Courtesy: Platt.



Conduit expansion couplings shown.



LFMC conduit expansion joint installed.

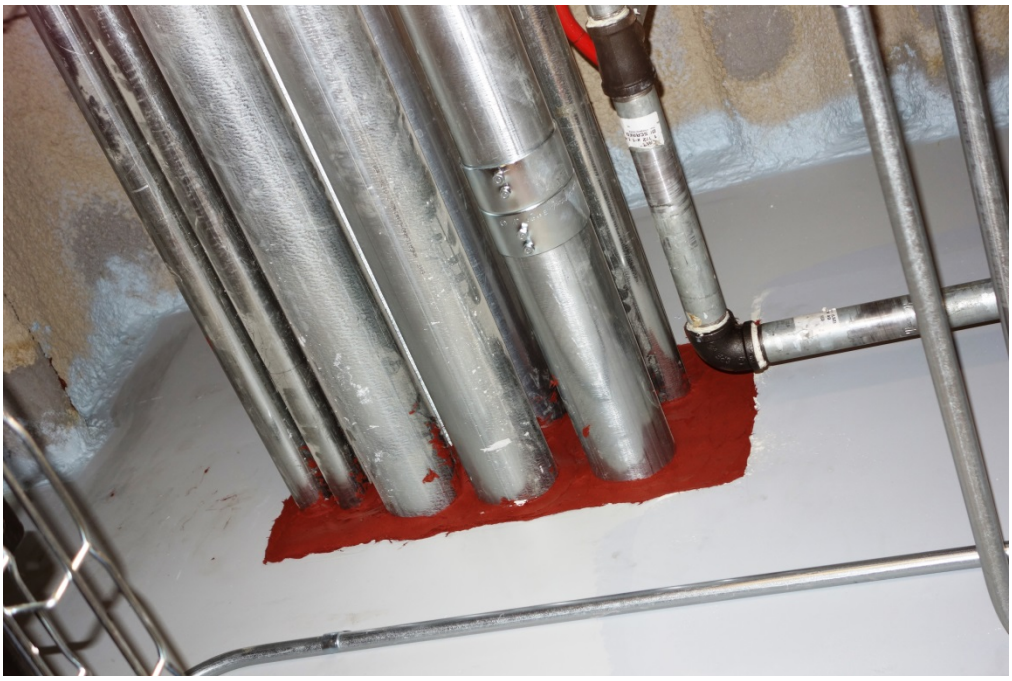
LFMC conduit expansion joints shown.

1.10. BD > ISP > PATHWAYS > CONDUIT > FIRESTOPPING

1.10.1. All penetrations made through fire-rated structures by conduits, cables, innerducts, cable trays, and duct banks shall be sealed with NEC and City of Los Angeles- approved firestopping materials.

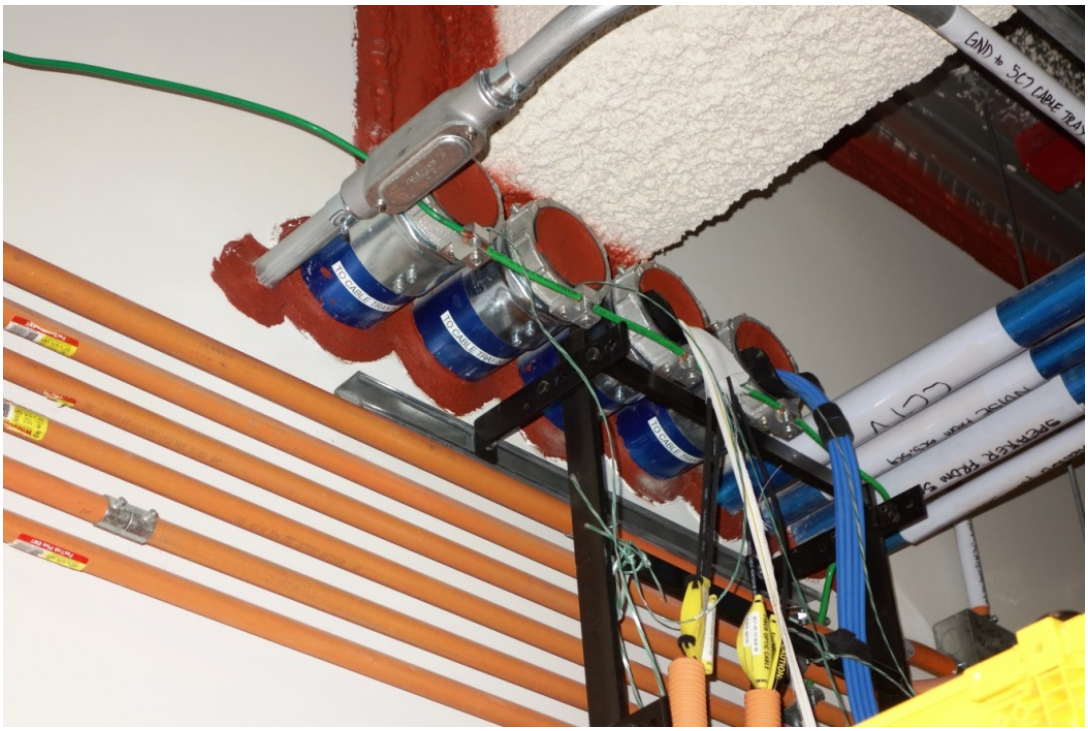
Firestop putty around all individual wall penetrations by conduit.

1.10.2. Firestopping materials shall be sufficient to restore the fire-rating of the penetrated structure.



Firestop putty around all individual conduits in a common wall entry.

1.10.3. Putty-type firestopping material is preferred for ease of firestop reentry.



Firestop putty is shown around all Horizontal Distribution conduits.

1.10.4. Specified Technologies Inc. (STI) Firestop E-Z Path or equivalent is also allowed through walls.

1.11. BD > ISP > PATHWAYS > CONDUIT > PULL ROPE

1.11.1. All conduits and innerducts (backbone and horizontal) shall have pull ropes (strings) unless full of cables.

Empty conduits are shown with pull strings and ropes.

1.12. BD > ISP > PATHWAYS > CONDUIT > RISERS

1.12.1. Risers are vertical pathways used to connect multiple levels of a building for cable installation. Risers can be as small as a 4-inch conduit between floors or as large as a separate room used as a conduit chase.

A small conduit riser shown with large pull box.

A conduit chase (riser room) as a dedicated pathway in a large facility is shown.

1.13. BD > ISP > PATHWAYS > CONDUIT > SLEEVES/SLOTS/STUB-OUTS

1.13.1. Through-the-wall or through-the-floor conduit stub-outs (sleeves) should extend a minimum of 3-inches and no more than 6 inches, just sufficiently to install bushings, grounding, and labels. Conduit sleeves in the ceiling can be as long a required to reach within 12-inches of a cable tray.

1.13.2. Conduit slots are allowed and should be as flush against the wall as practical.

1.13.3. Conduits shall be anchored to floor or wall-mounted strut.

Conduit stub-ups shown secured to floor-mounted strut.

1.13.4. Conduit connectors and couplers shall not be placed within slots or sleeves.

1.13.5. All coring's, sleeves/slots shall use firestop material.

1.13.6. All empty conduits shall have firestop putty or conduit plugs.

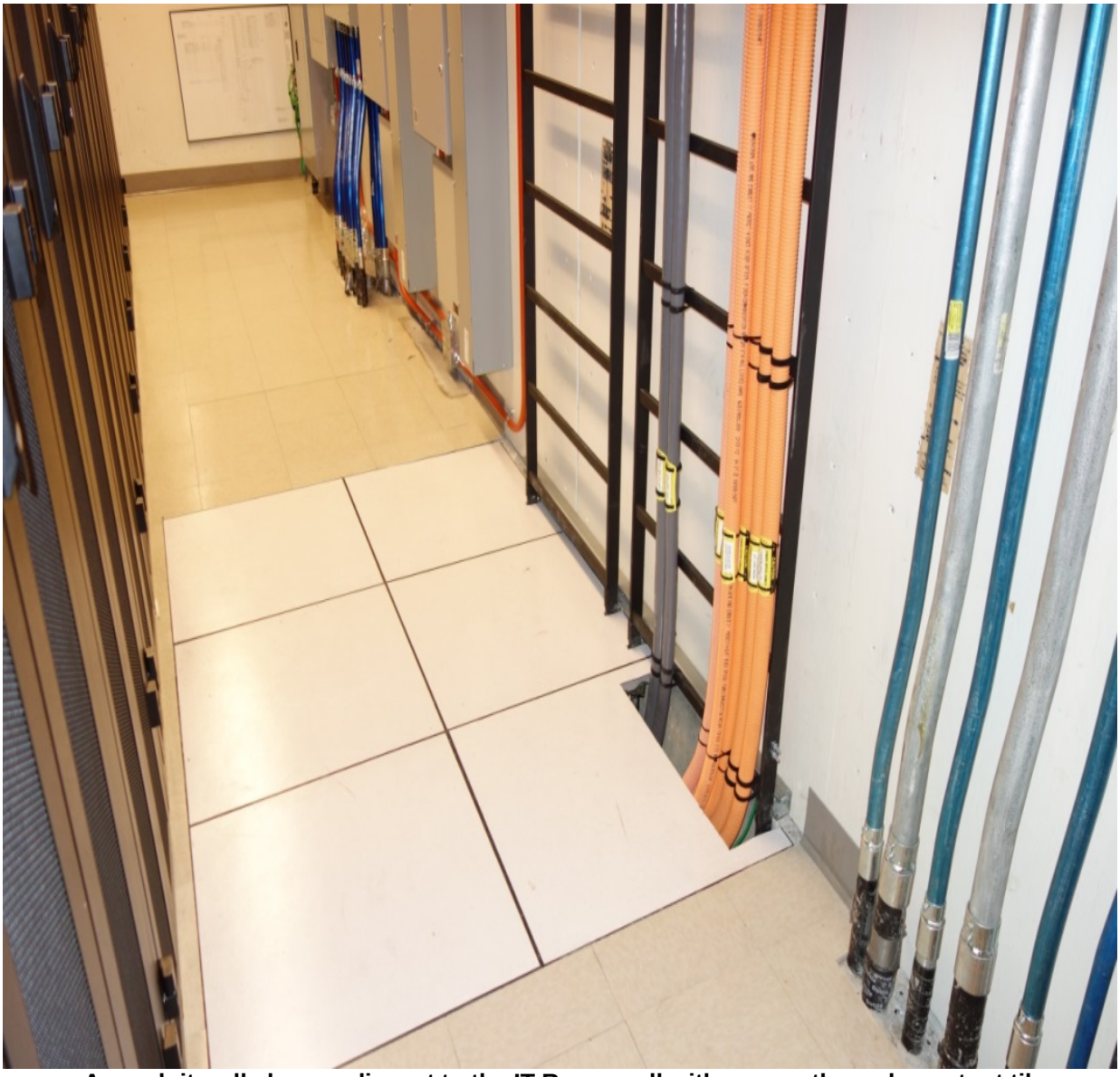
Conduit stub-ups shown secured to wall-mounted strut.

1.14. BD > ISP > PATHWAYS > CONDUIT > WELLS

1.14.1. In-slab conduit wells are allowed to connect IT Rooms as part of a poured concrete building foundation.

A conduit well shown away from the IT Room wall with cables as a trip hazard.

1.14.2. Conduit wells shall be placed near the IT Room wall so that cables can enter through a cutout in the access floor tile and not be exposed as a trip hazard.



A conduit well shown adjacent to the IT Room wall with access through a cutout tile.

Conduit wells shall be nest to the IT Room wall so that cables are not a trip hazard as shown here.

1.14.3. Conduit Well access points shall be a minimum of 48" W x 72" L. Depth is determined by the number of conduits.

1.14.4. Conduit Wells can also used as a pass-through to distant IT Rooms.

1.14.5. Conduit Well access shall be accessible through raised access floor panels supported by pedestals and stringers.

1.14.6. Floor support pedestals shall bonded to the floor with epoxy and shall be grounded to the TGB.

1.14.7. Conduit Wells shall have 400 lb.-rated cable support racks to hold cables and splice cases.

1.14.8. All conduit openings shall be plugged with firestop and/or duct plugs.

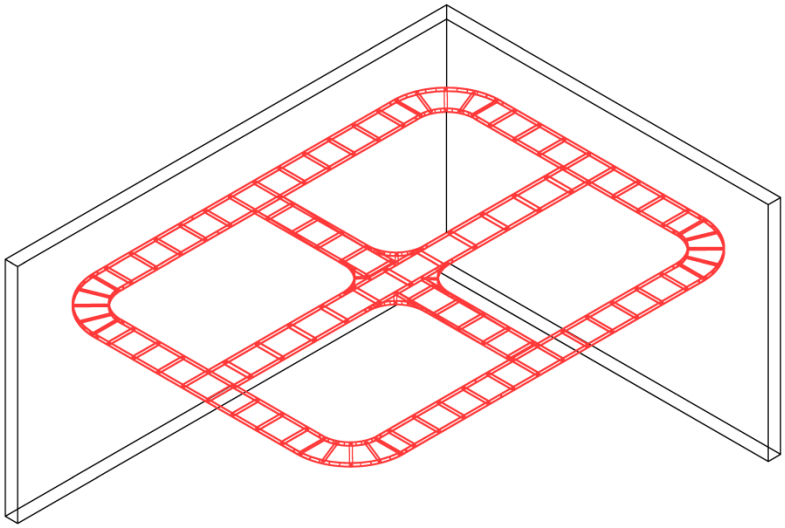
Conduit well showing cable support, fabric innerduct, firestop, and conduit plugs.

1.14.9. In an IT Room with a Conduit Well, each IT cabinet shall be fed with two (2) 4-inch under-floor conduits.

1.14.10. Conduit Wells may be used for Coyote-type splice cases.

1.15. BD > ISP > PATHWAYS > CABLE TRAY > INSIDE IT ROOMS

1.15.1. MPOE's and IT Rooms shall have either a minimum 12-inch W x 4inch H Cable Tray or a minimum 18-inch W Ladder Rack (not wire basket) around the room perimeter, down the middle of the room centered over the tops of the equipment cabinets, and across the center of the room.



Cabletray/Ladder Rack is required around the perimeter, over the cabinets, and across the room.

1.15.2. *Cable tray/Ladder Rack* are used inside IT Rooms for copper and fiber cables. Fiber jumpers shall be separated from cables by using wire baskets.

Wire Basket for fiber jumpers is shown attached to Ladder Rack. Cable waterfalls are required.

1.15.3. MPOE and IT Room layouts that have two rows of equipment cabinets shall have horizontal Cable Tray or *Ladder Rack* centered over each row and connected to the perimeter ladder rack.

1.15.4. MPOE and IT Rooms shall have an additional lateral cable tray/Ladder Rack installed to divide the room in half.

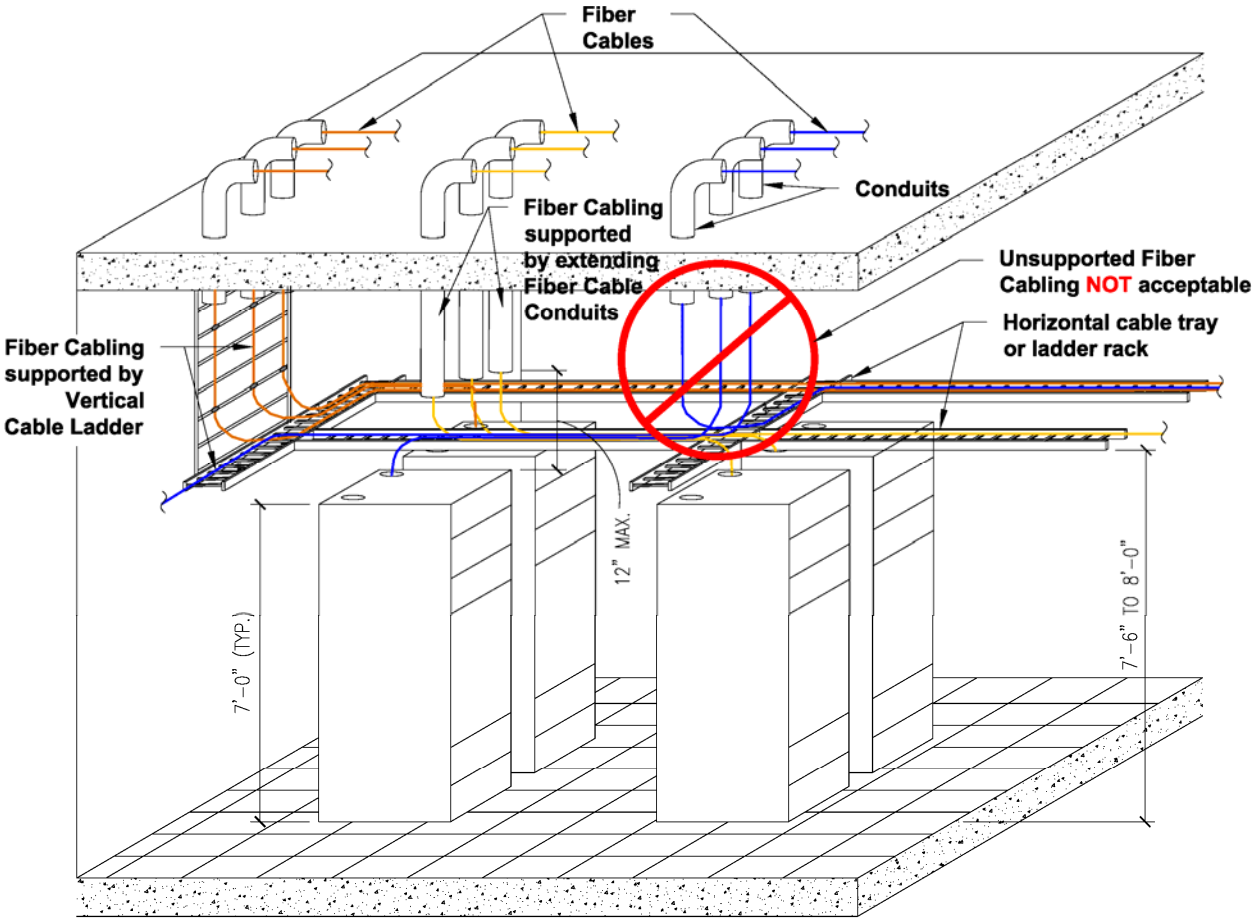
Cable Tray that cannot reach perimeter walls due to obstructions shall have an additional lateral.

1.15.5. Vertical *Ladder Rack* shall be installed on walls to support cables entering MPOE's and IT Rooms from the floor above or below. Vertical *Ladder Rack* shall be sized for the maximum number of cables for the conduit capacity installed plus 50% growth.

Cables routed down a wall to floor conduits shall be mounted to vertical Ladder Rack for support.

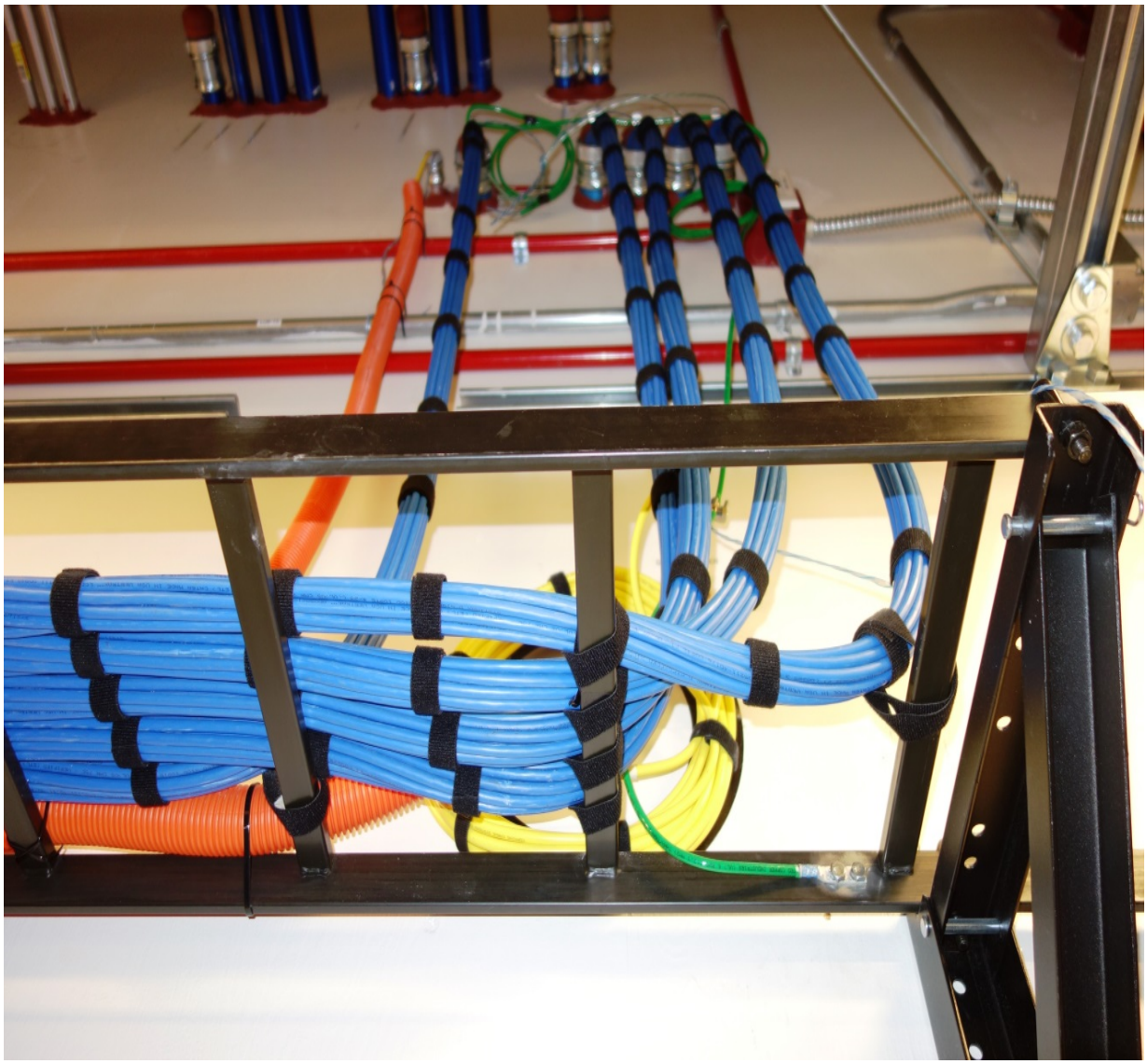
In IT Rooms, vertical Ladder Rack is required to secure cables that transition to floor conduits.

1.15.6. All above-ceiling and above-cabinet Cable Tray, Ladder Rack, and Wire Baskets shall have cable support waterfalls to transition from horizontal to vertical direction within 12-inches of Cable Tray, Ladder Rack, and Wire Baskets.



Vertical cable tray supports cables to the horizontal cable tray when conduits do not reach.

In IT Rooms, vertical Ladder Rack is required to secure cables for conduits that don't reach within 12-inches of the cable tray or ladder rack.



A vertical Ladder Rack is required to support long cable drops, and is missing here.

1.15.7. *Wire Basket* shall be used for above-cabinet fiber jumper pathways.

Wire Basket shall be attached to Cable Tray or Ladder Rack. Cable waterfalls are required.

1.15.8. *Wire Basket* used for above-cabinet fiber jumper pathways shall be attached to *Ladder Rack* or *Cable Tray* in MPOE and IT Rooms. Such *Wire Basket* shall continuously connect adjacent cabinets within a row and adjacent rows of cabinets.

Wire Basket requires cable waterfalls to maintain fiber optic bend radii.

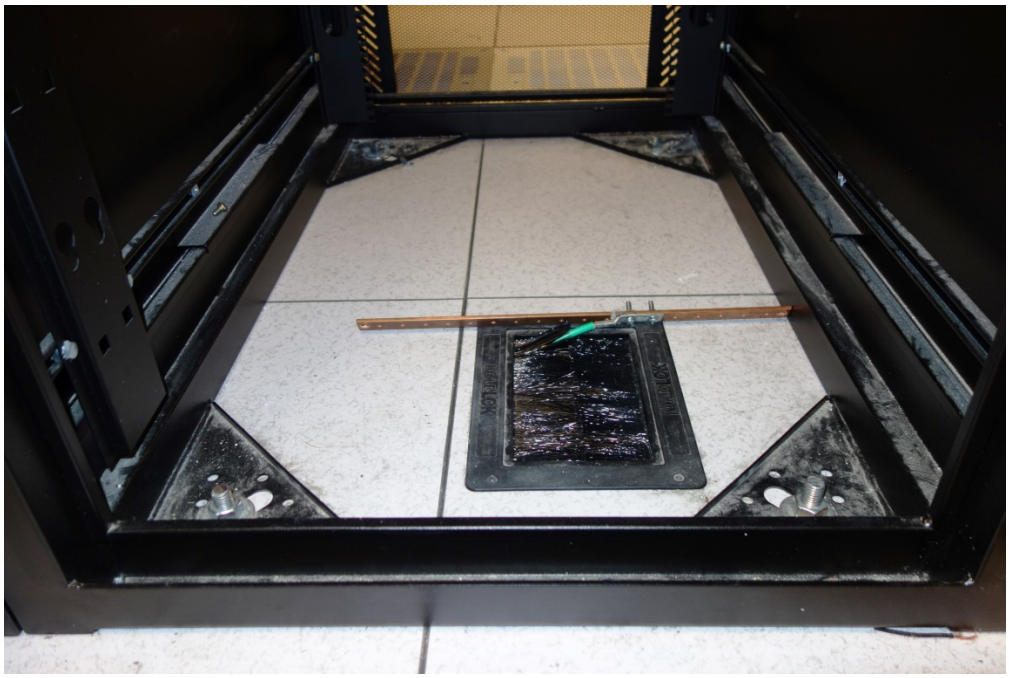
1.15.9. *Wire Basket* shall be used under raised access floors for pathways. Underfloor pathways shall be separated between cables and jumpers.

1.15.10. All *Wire Basket* shall be either electroplated zinc or ANSI type 304 stainless steel and have a working load designed for the location.

Wire basket shown running under a raised access floor for horizontal cables in an IT Room.

1.15.11. *Wire Basket* used under raised access floors shall be installed to provide pathways for all possible cable connections.

1.15.12. *These Wire Baskets shall* be installed underneath and towards the rear of the cabinets to facilitate cable entry through floor-mounted brush grommets.



A brush grommet through an access floor is shown near the back of the cabinet.

1.15.13. *Fiber Trough* shall not be used for above-cabinet fiber jumper pathways.

Fiber Trough shall not be used because of the difficulty aligning with cabinet chase nipples.

1.15.14. All *Cable Tray*, *Ladder Rack*, and *Wire Basket* hardware shall have less than 3/8-inch length of threads exposed. All exposed threads over 3/8-inch length shall require plastic boots

Mounting and grounding hardware shall not stick out more than 3/8-inch without caps (in red).

1.15.15. All metallic Cable Tray, Ladder Rack, and Wire Baskets shall have their individual sections grounded to the TMGB or TGB within the room.

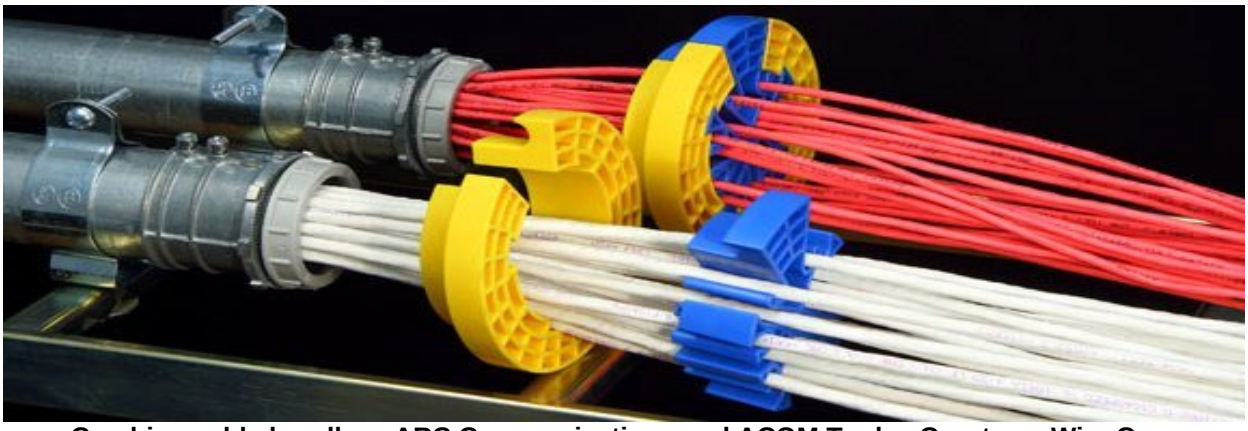
1.15.16. *Cable Tray*, *Ladder Rack*, and *Wire Basket* left over from a project shall be removed and properly disposed from the work site.

1.15.17. All *Cable Tray*, *Ladder Rack*, and *Wire Basket* shall be accurately documented on As-Built drawings.

1.15.18. All *Cable Tray*, *Ladder Rack*, and *Wire Basket* shall have their cables and innerducts combed and bundled professionally using a cable comb or equivalent tool.

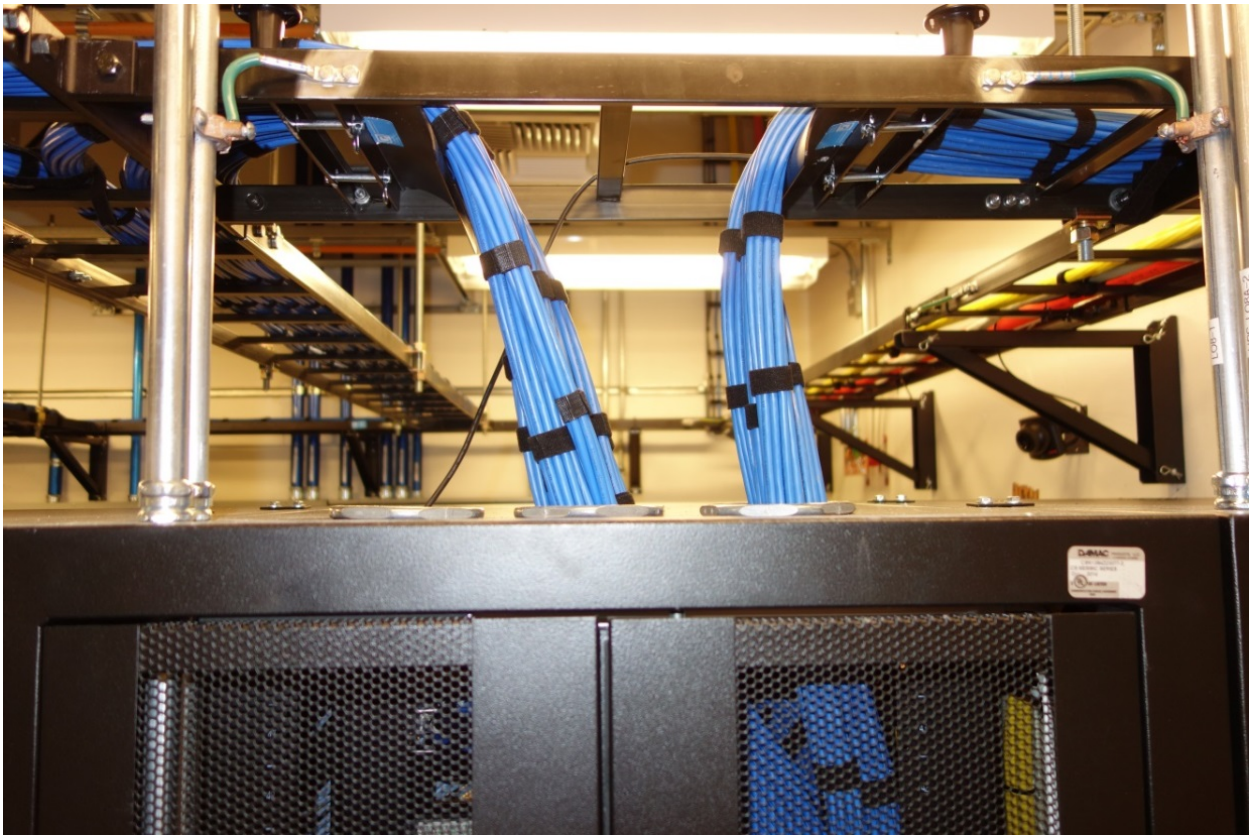
Cable Trays shall have neat combed cable bundles & straight cable lines.

Combing a cable bundle. Courtesy: Cablecomb.



Combing cable bundles. ARC Communications and ACOM Tools. Courtesy: Wire Care.

1.15.19. Conduit and Wire Basket Waterfalls shall align with the cabinet conduit case nipples.



Ladder Rack cable waterfalls are required to transition cable from horizontal to vertical.

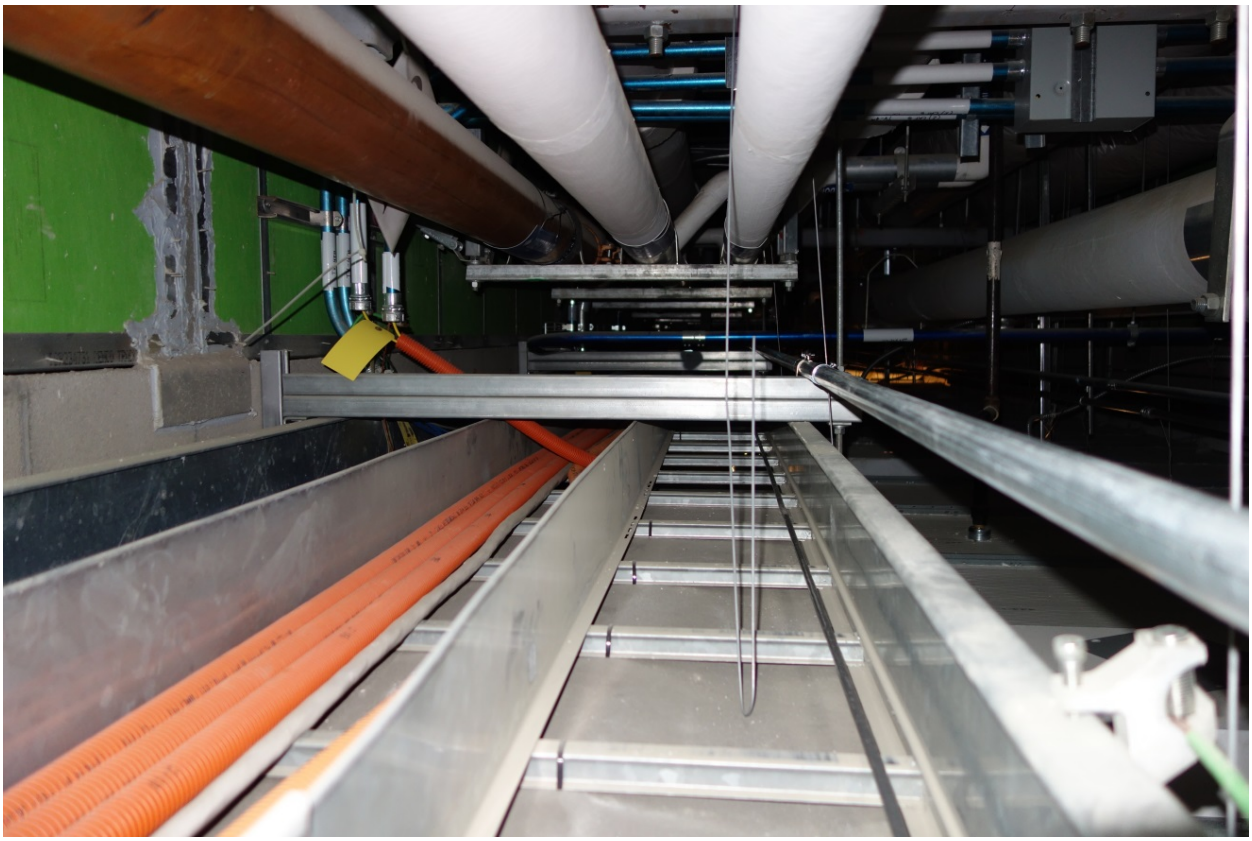
1.16. BD > ISP > PATHWAYS > CABLE TRAY > OUTSIDE OF IT ROOMS

1.16.1. Horizontal common-use, aluminum *Cable Tray* (not ladder rack and not wire basket) may be installed within a facility as a common backbone pathway for indoor use or within MPOE and IT Rooms instead of conduits.

1.16.2. Horizontal common-use *Cable Tray* shall be accessible from common corridors - not from within tenant spaces.

1.16.3. Horizontal common-use *Cable Tray* shall be sized at a minimum of twenty-four (24) to thirty-six (36) inches wide by four (4) to six (6) inches tall (depending on manufacturer's tray fill calculations), and shall have a ladder rack bottom and an uncovered top.

1.16.4. Horizontal common-use *Cable Tray* shall have a divider down the center to separate LAWA from tenant cables.



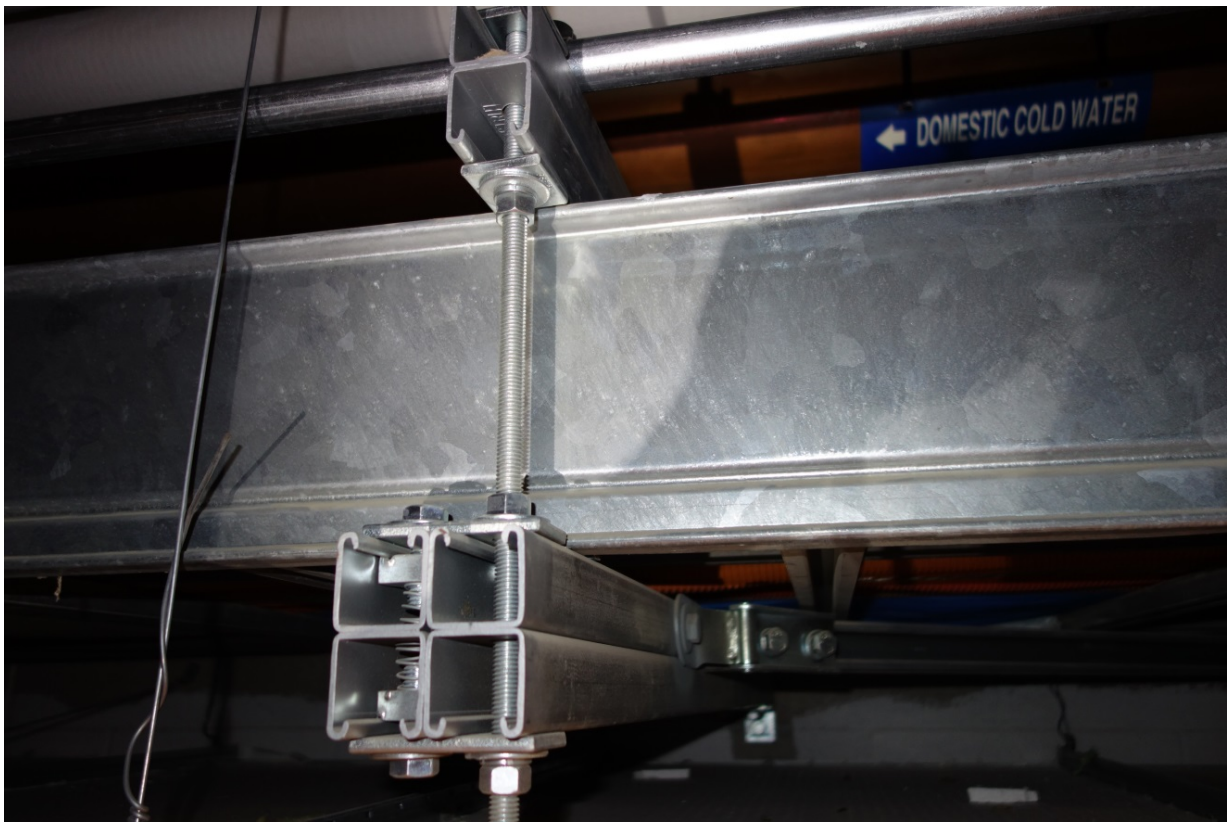
An outside IT Room Cable Tray requires a divider wall to split space for LAWA and TCWC's.

1.16.5. Horizontal common-use Cable Tray does not substitute for the required two (2) 4-inch backbone conduits from the MPOE to each LAWA IT Room.

1.16.6. If the ceiling stub-out conduits to the cable tray exceeds 12-inches, then vertical common-use Cable Tray shall be attached to the ceiling (or beams above the ceiling) to support cables from the floor above entering the horizontal common use Cable Tray.

1.16.7. Horizontal common-use Cable Tray shall be sized for the calculated load.

1.16.8. Horizontal common-use Cable Tray shall be installed and anchored with support materials that are sized for the load.



Cable Trays require trapeze-style support sized sufficiently for the calculated maximum load.

1.17. BD > ISP > PATHWAYS > J-HOOKS

1.17.1. J-Hooks are not permitted in passenger terminals.

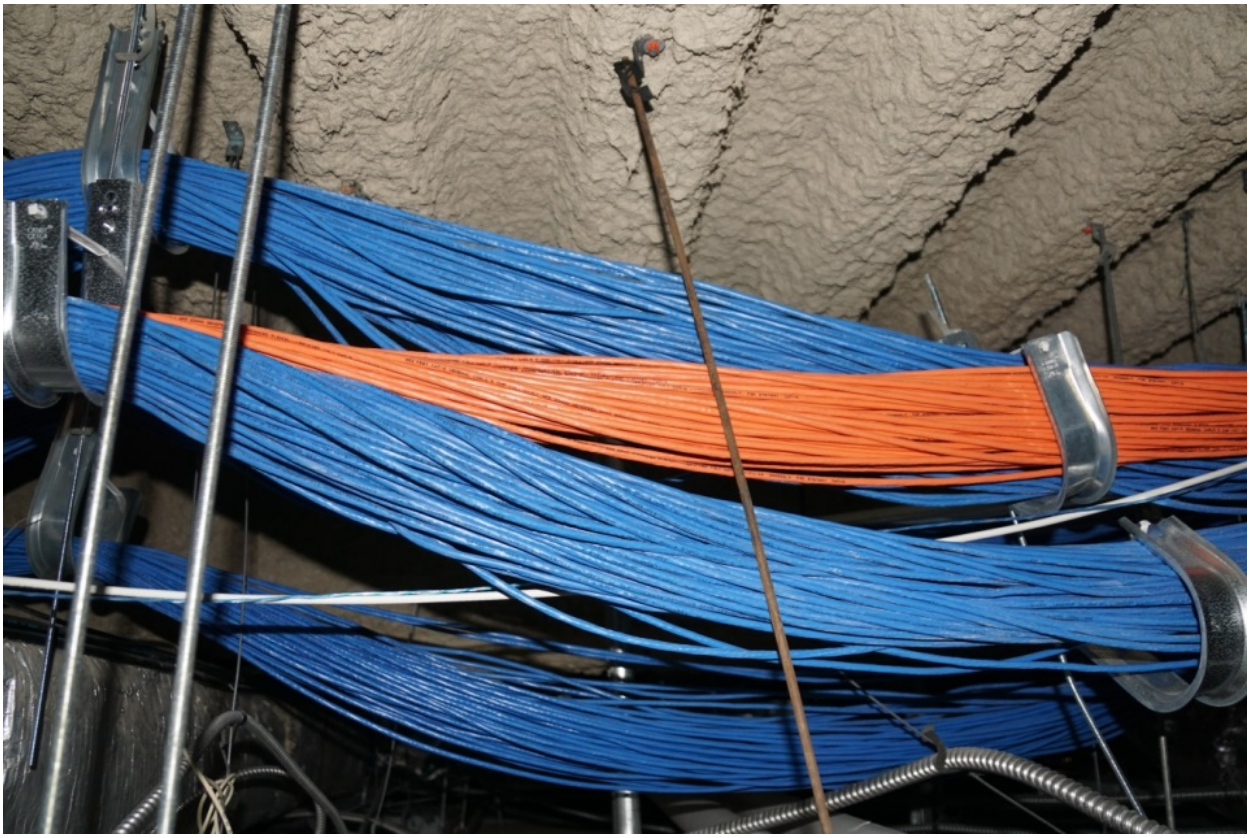
1.17.2. J-Hooks are permitted in non-passenger terminal buildings.

1.17.3. J-Hooks shall be spaced every 36-inches or less if required by Los Angeles Building Code or cable load. **Note:** This is more stringent than the Standards. Failure to comply will result in additional J-Hooks being required to be installed.

1.17.4. J-Hooks may be anchored to the ceiling with either threaded rod or drop wires that are sized for the weight.

A simple J-Hook installation is shown.

1.17.5. Ceiling-anchored drop wires supporting J-Hooks shall be secured to the T-Bar ceiling with drop wire to Tee Bar securing clips.



The problem with large quantities of cables on J-Hooks is that the supports get bent.

1.18. BD > ISP > PATHWAYS > WIREWAY (GUTTER)

1.18.1. Wireways are metal pathways for combining and concealing large numbers of wires.

1.18.2. Wireways are used to aggregate IT System wires.

1.18.3. Wireways are also used to contain large numbers of fiber jumpers terminating into wall-mount patch panels.

Wireway can be used for aggregate cabling of an IT system. Pull strings are required for conduits.

Wireway is shown with cable slack loops for an IT system.

Wall-mounted fiber patch panels shall have wireway installed around and between panels.

A bank of wall-mounted fiber patch panels shown with interconnecting wireway.

Side view of a wall-mounted fiber patch panels with interconnecting wireway and stand-offs.

1.19. BD > ISP > PATHWAYS > JUNCTION BOXES

1.19.1. Junction boxes larger than 24" x 24" shall have hinged covers.

Ceiling and beam-supported junction boxes are shown.

A wall-supported junction boxes is shown.

1.20. BD > ISP > PATHWAYS > PULLBOXES

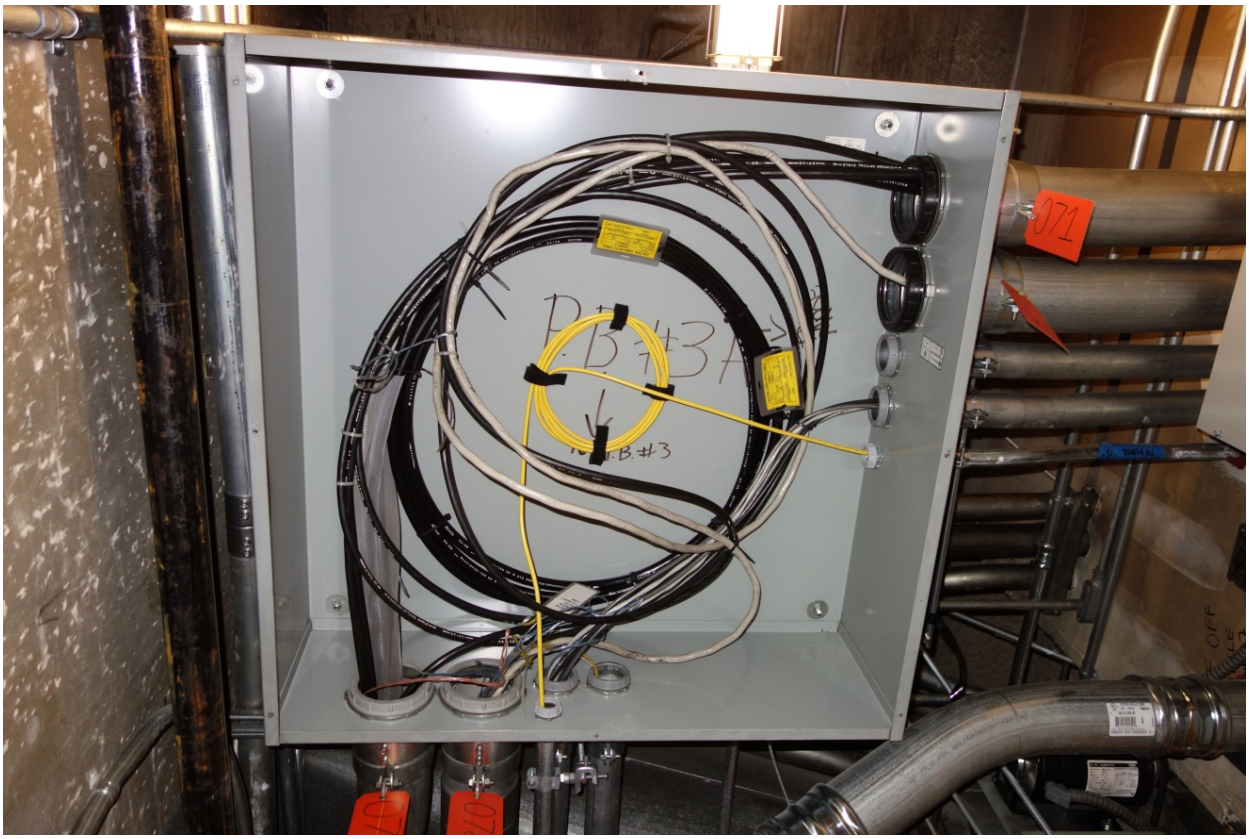
1.20.1. Pull boxes are allowed on long cable pulls.

Pull boxes on straight runs for long cable pulls.

1.20.2. Pull boxes are allowed to change conduit direction.

Pull box for a 90-degree conduit direction change.

1.20.3. Pull boxes are allowed to store cable slack.



Large pull box for direction change and with slack cable loops.

1.20.4. Pull boxes used to store cable slack shall anchor the slack loop into the pull box metal.

1.20.5. Adhesive cable anchors are not permitted unless permanently anchored into the pull box using screws.

1.20.6. Pull boxes that are 24-inches square or greater shall have piano-hinge covers.

1.20.7. Pull boxes with hinges shall have unobstructed access.

Indoor pull boxes that are 24-inches square or greater shall have piano-hinge covers.

Outdoor pull boxes that are 24-inches square or greater shall have piano-hinge covers.

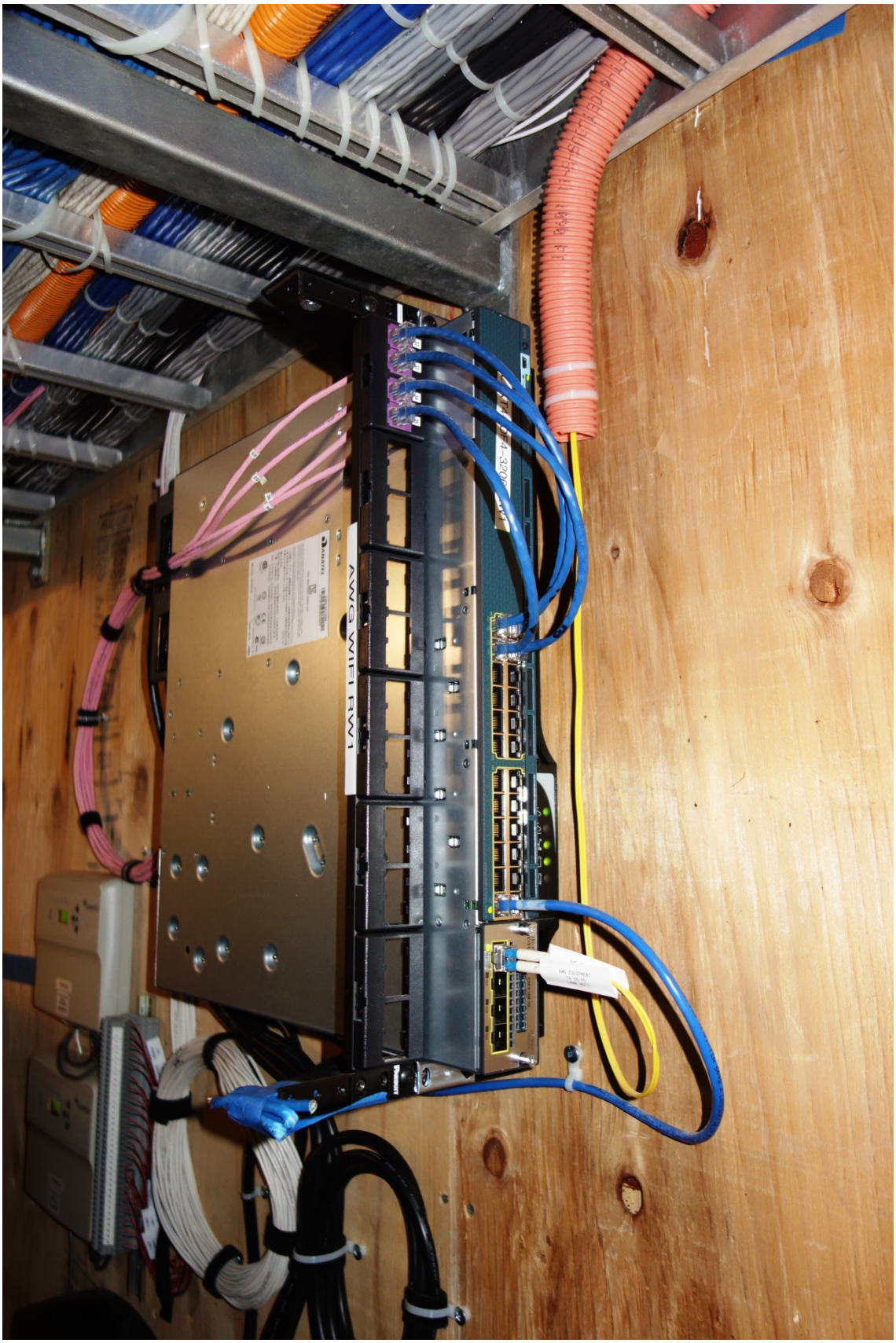
1.21. BD > ISP > PATHWAYS > INNERDUCTS

1.21.1. Orange corrugated High Density Polyethylene (HDPE) innerducts shall only be used to protect fiber cables between conduits and are not to be used inside conduits because they take up too much space. However, HDPE innerduct may entend within conduit by not more than 6-inches for protection of cables that do not transition to fabric innerduct.

Conduits shown with HDPE innerduct that may stick inside conduit up to 6-inches.

1.21.2. Empty HDPE innerducts shall have pull strings.

1.21.3. Fiber cables and jumpers transitioning from fabric innerduct within conduit to an equipment cabinet, junction box or patch panel within an IT Room shall be protected with orange corrugated HDPE plastic innerduct up to and inside the enclosure or cabinet housing the patch panel.



Exposed fiber jumpers shall be protected to the equipment or conduit.

1.21.4. HDPE innerducts may be secured with ty-wraps.

1.21.5. A minimum of one of the inside conduits from the MPOE to each IT Room shall be filled with three (3), 3-inch, 3-cell, Maxcell fabric innerducts shall be used within 4-inch conduits.

1.21.6. Backbone conduits from the MPOE to the local IT Rooms shall have a minimum of one 4-inch conduit filled with Maxcell fabric innerducts.

The transition from HDPE innerduct to Maxcell fabric innerduct within conduits is shown.

1.21.7. Fabric innerduct shall be tied off at each end.

1.21.8. Innerducts shall be secured to ladder racks or other physical supports.

1.21.9. Conduits with innerducts shall be firestopped.

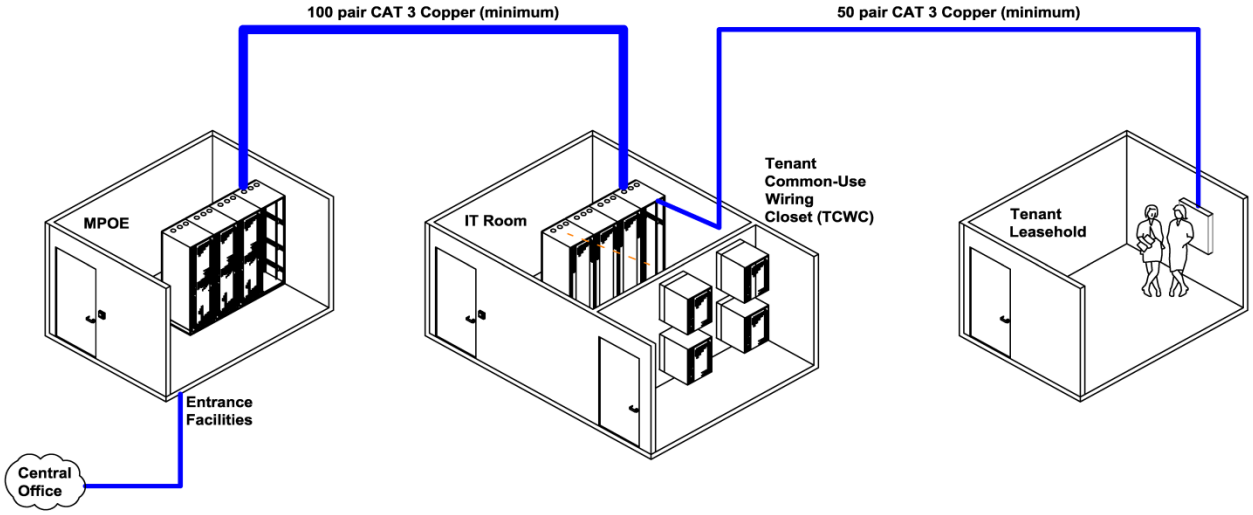
1.22. BD > ISP > CABLE > COPPER > CATEGORY 3

1.22.1. All new IT Rooms shall have a minimum of 100-pair CAT 3 cables installed from the MPOE.

Backbone inside plant CAT 3 copper cables being distributed from an MPOE to local IT Rooms.

1.22.2. Cables shall be terminated on 110 blocks either on the wall or within the infrastructure cabinet in the IT Room on a frame suitable for installation.

1.22.3. 50-pair of the 100-pair for each IT Room shall be extended to adjacent Tenant Common-Use Wiring Closets (TCWC's) if nearby.



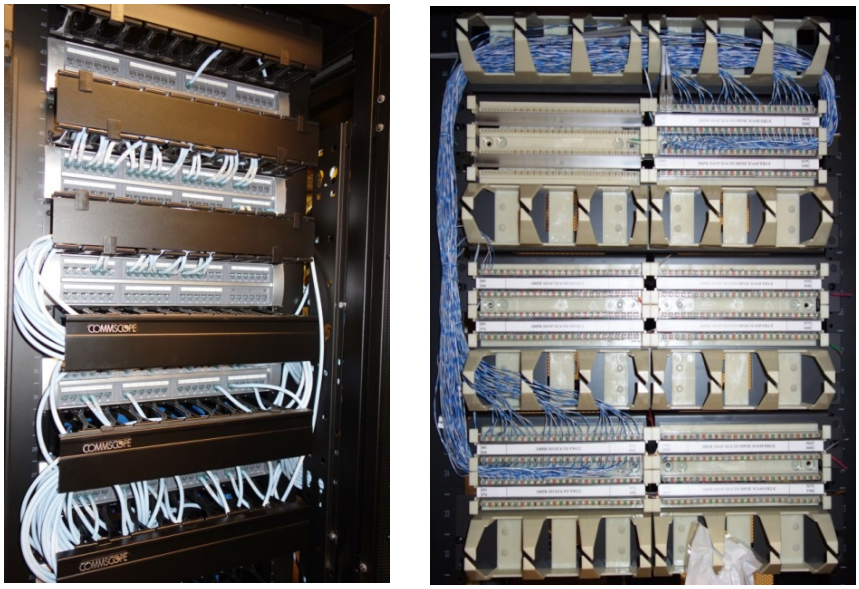
Backbone inside plant CAT 3 copper cables are extended from MPOE to IT Room to TCWC.

1.22.4. 24 AWG, solid, flame-retardant, cross-connect wire that is rated for 16 MHz shall be used for CAT 3 jumpers. Jumpers may be colored blue/white, red/white, green/white, or blue/yellow.

1.22.5. Cat 3 cable shall have cable management and be neatly and professionally dressed without any binding points.

1.23. BD > ISP > CABLE > COPPER > CABLE MANAGEMENT

1.23.1. All cables shall be neatly and professionally bundled, dressed, secured with Velcro-type fasteners (not cable ties), and labeled. Bend radii shall meet or exceed LAWA's standards.



Neat cable management for CAT 6A and rack-mounted 110 blocks.

1.23.2. All cables in Cable Tray, Ladder Rack, and Wire Basket shall be combed and neatly and professionally bundled, dressed, secured, and labeled. Cables shall follow parallel lines and wide sweeping bends.

1.23.3. Patch panels installed in the newer 34-inch wide cabinets shall have cables swept horizontally to the cable management areas in each side of the cabinet. From cabinet centerline, cables to the left of centerline shall be swept and dressed to the left into the cabinet cable management space, and cables to the right of centerline shall be swept and dressed to the right into cabinet cable management space.

1.23.4. Wall-mount 110 and 66 blocks shall have a 2RU or larger horizontal cable manager with cable retention fingers. Jumpers shall be neatly dressed and bundled to meet or exceed LAWA's maximum bend radii standards.

1.23.5. D rings for wall-mount cable management is acceptable.

1.23.6. For renovations, in addition to above, legacy patch panels and network switches shall have a 2RU horizontal cable manager with cable retention fingers and a cover below the equipment.

1.24. BD > ISP > CABLE > COPPER > MAIN DISTRIBUTION FRAME

1.24.1. Within the MPOE of new or renovated terminal construction, large quantities of backbone copper cables shall terminate in a dedicated Main Distribution Frame (MDF) room on 110 blocks in racks (not cabinets).

Front View of an MPOE MDF shown with racks of 110 Blocks for Copper BD.

Rear View of an MPOE MDF shown with racks of 110 Blocks for Copper BD.

1.25. BD > ISP > CABLE > FIBER

1.25.1. Singlemode fiber shall be installed. Multimode fiber shall not be installed.

1.25.2. All inside plant fiber optic cables shall use Corning SMF28e+ glass with bend-insensitive additive code "H" (aka Ultra) and Corning tight buffer MIC jacketing. See Appendix N for exceptions.

1.25.3. Outside plant fiber optic cables shall use Corning SMF28e+ glass with bend-insensitive additive code "H" (aka Ultra) and Corning loose tube Altos jacketing. See Appendix N for exceptions.

A sample of acceptable singlemode fiber type jackets are shown.

1.25.4. Inside plant cables that are required to enter facilities more than 50 feet shall use Corning SMF28e+ glass with bend-insensitive additive code "H" (aka Ultra) and Corning Freedm® jacketing. See Appendix N for exceptions.

1.25.5. The minimum fiber count from the MPOE to each individual IT Room is 72-strands of singlemode fiber.

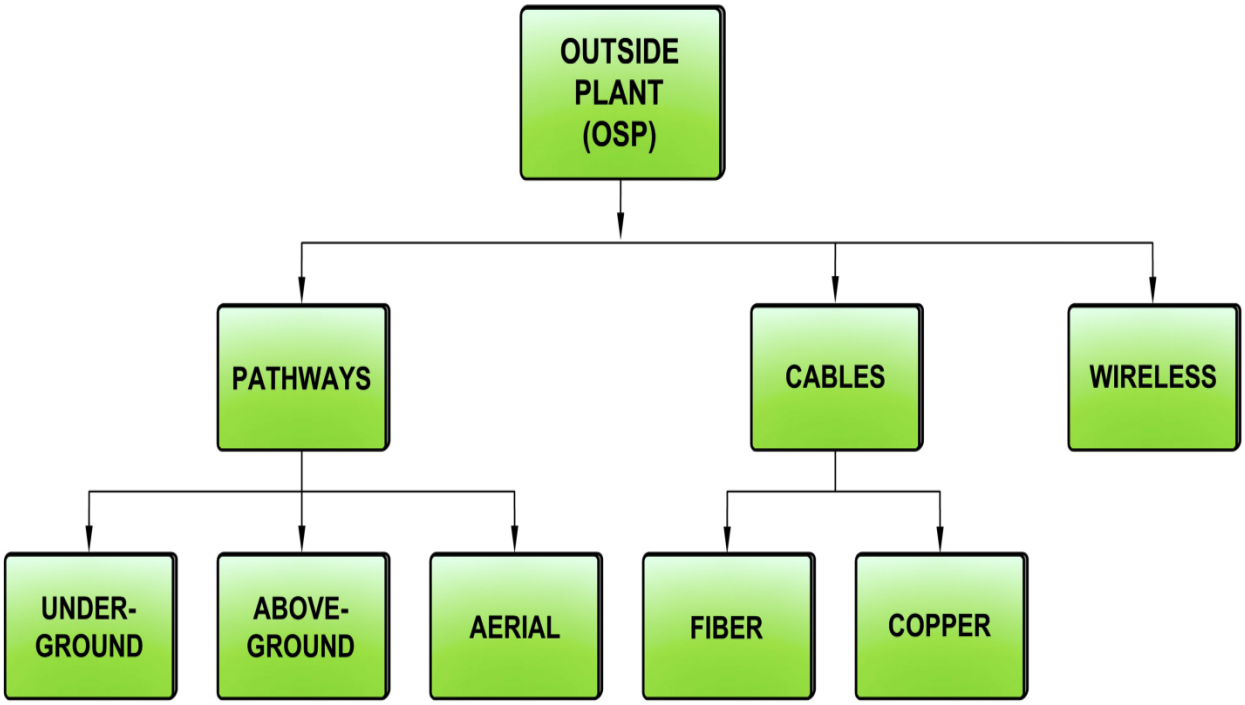
1.26. BD > OUTSIDE PLANT (OSP)

1.26.1. Outside plant is the collection of all outdoor pathways, cables, and wireless, that is used to transport voice, video, and data.

1.26.2. OSP pathways include underground, above ground, aerial, and wireless.

1.26.3. OSP cables include optical fiber, CAT 3 backbone, coax, and low-voltage instrumentation-type conductors.

1.26.4. Backbone wireless is typically between buildings or repeater sites and is used to carry voice, video, and data from one facility to another.



A flowchart of the typical Outside Plant components.

1.27. BD > OSP > PATHWAYS > CONDUIT

1.27.1. All passenger terminals and LAWA office buildings shall have a minimum of four (4) entrance facility conduits.

1.27.2. Entrance facility conduits shall be a minimum of 4-inch in size.

1.27.3. Underground ductbank conduits shall be a minimum of 4-inches in size.

An Entrance facility pull box.

1.27.4. Galvanized rigid conduit shall be used for temporary (less than five years) communications pathways above ground, alongside buildings/trailers, or attached to fences.

A sample of a temporary conduit installation using galvanized rigid conduit.

A temporary transformer using galvanized rigid conduit is shown.

1.27.5. Conduit shall be sized for the required 40% fill in compliance with the National Electric Code (NEC).

1.27.6. An open trench will not be allowed on the airfield unless pre-approved by LAWA Operations.

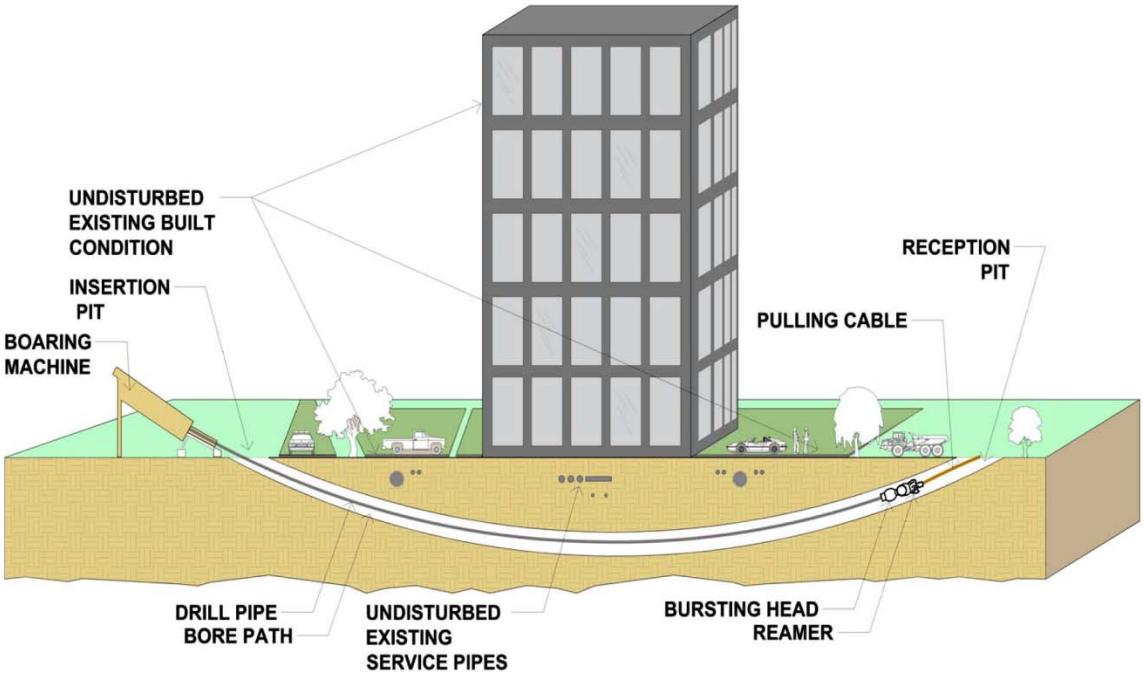
1.27.7. Large pull/Junction boxes shall be used as necessary to provide a pull point and change in conduit direction.

1.28. BD > OSP > PATHWAYS > CONDUIT > BORING

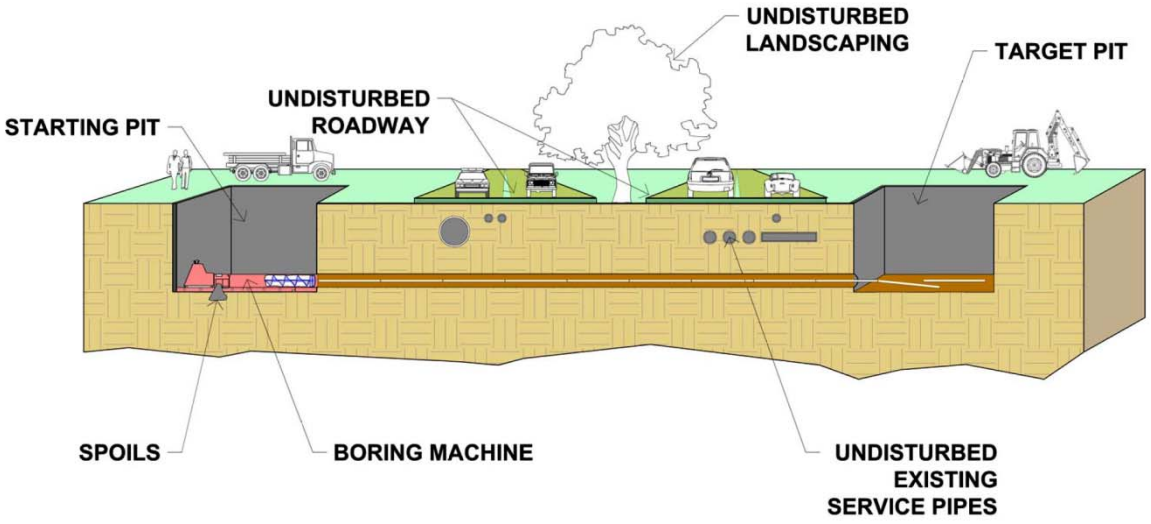
1.28.1. All directional boring requires LAWA pre-approval.

1.28.2. All boring shall comply with industry standards and best practices.

1.28.3. Auger boring requires casing sleeves to be installed.



Directional boring diagram.



Jack-n-Bore diagram.

1.29. BD > OSP > PATHWAYS > CONDUIT > DUCTBANKS

1.29.1. Poly Vinyl Chloride Schedule 40 can be used for underground ductbanks provided that they are enclosed in concrete.

1.29.2. Communications underground ductbanks shall have a minimum of four (4) 4-inch entry and four 4-inch exit.

1.29.3. Ductbank conduits shall be installed using conduit spaces to separate conduits for concrete inter-penetration.

Conduit spacers shown for separating conduits in a ductbank. Courtesy: Carlon.

A ductbank using PVC concrete-encased conduits is shown with detectable I.D. tape.

1.30. BD > OSP > PATHWAYS > CONDUIT > PROTECTORS

1.30.1. All temporary conduits that must cross driveways shall be galvanized rigid steel.

1.30.2. All temporary conduits and outdoor cables that must cross driveways shall be protected from vehicular traffic with heavy duty protectors designed for the purpose.

Conduit-protector in driveway protecting conduit.

Conduit-protector at fuel pump protecting conduit.

1.31. BD > OSP > PATHWAYS > CONDUIT > TRENCHING

1.31.1. Trenching is the preferred method of installing outdoor conduits and cables followed by boring.

1.31.2. Burial depths of trenches shall follow the National Electric Code (NEC).

Trench depth per the National Electric Code.

1.31.3. The ground shall be scanned for existing utilities before trenching.

1.31.4. All existing utilities shall be protected in place.

1.31.5. Conduits shall be encased in concrete with a minimum 2-sack slurry.

1.31.6. A detectable underground identification tape shall be installed over the entire line of trenching within 12-inches of the surface.

Underground detectable identification tape installed.

90 degree transition from horizontal to vertical.

1.31.7. Open trenches shall be protected by covering with traffic-rated steel plates that have been asphalted into position so they cannot move.

An open trench protected with steel plates asphalted in place.

An open trench protected with steel plates asphalted in place.

1.31.8. Trenches shall be delineated with orange cones and delineators.

An open trench delineated with orange cones.

1.31.9. The finished trench shall be filled concrete and/or asphalt to match existing landscape.

The finished trench matches the existing landscape.

1.32. BD > OSP > PATHWAYS > INNERDUCT

1.32.1. Corrugated HDPE innerducts shall not be installed in outdoor conduits - unless pre-approved by LAWA. Maxcell fiber innerducts shall be used.

1.32.2. A minimum of one outdoor conduit shall be filled with three (3), 3-inch, 3-cell, Maxcell fabric innerducts along the entire run of all ductbanks

A sample of outdoor fiber cables are shown installed in a 4-inch conduit with Maxcell innerducts.

A minimum of one conduit shall have (3) 3", 3-cell, Maxcell fabric innerducts per ductbank run.

1.32.3. All new fiber cables shall be installed within fabric innerduct.

1.32.4. Fabric innerduct shall be tied off at each end.

1.32.5. Innerducts shall be secured to cable racks or other physical supports.

1.32.6. Conduits with innerducts shall be firestopped or plugged.

1.32.7. Unless required by a Federal Agency, HDPE innerduct is not to be installed in outside plant due to inefficient use of conduits.

1.32.8. Three (3), 3-inch, 3-Cell, Maxcell fabric innerduct shall be installed within one of the 4-inch conduits in the ductbank.

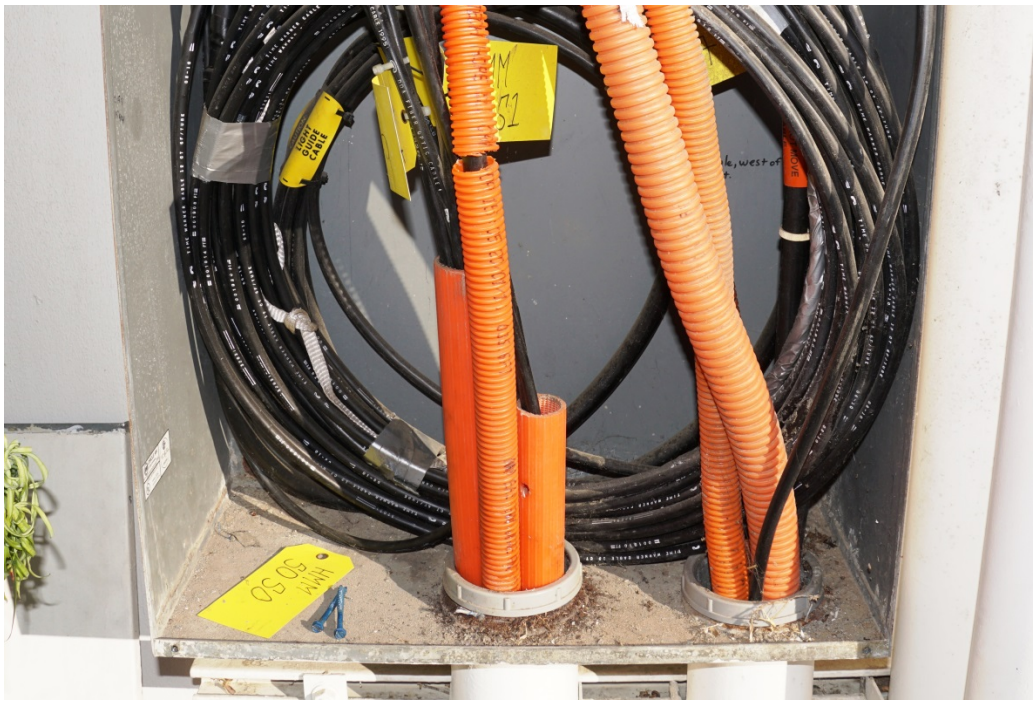
1.32.9. Innerducts shall not be spliced together within conduits.

1.32.10. All empty innerducts shall contain pullropes that are tied off at each end.

1.33. BD > OSP > PATHWAYS > INNERDUCT REMOVAL

1.33.1. All innerducts with cables shall use the MaxSpace Recovery process if innerduct removal is required to make additional cable space in conduits.

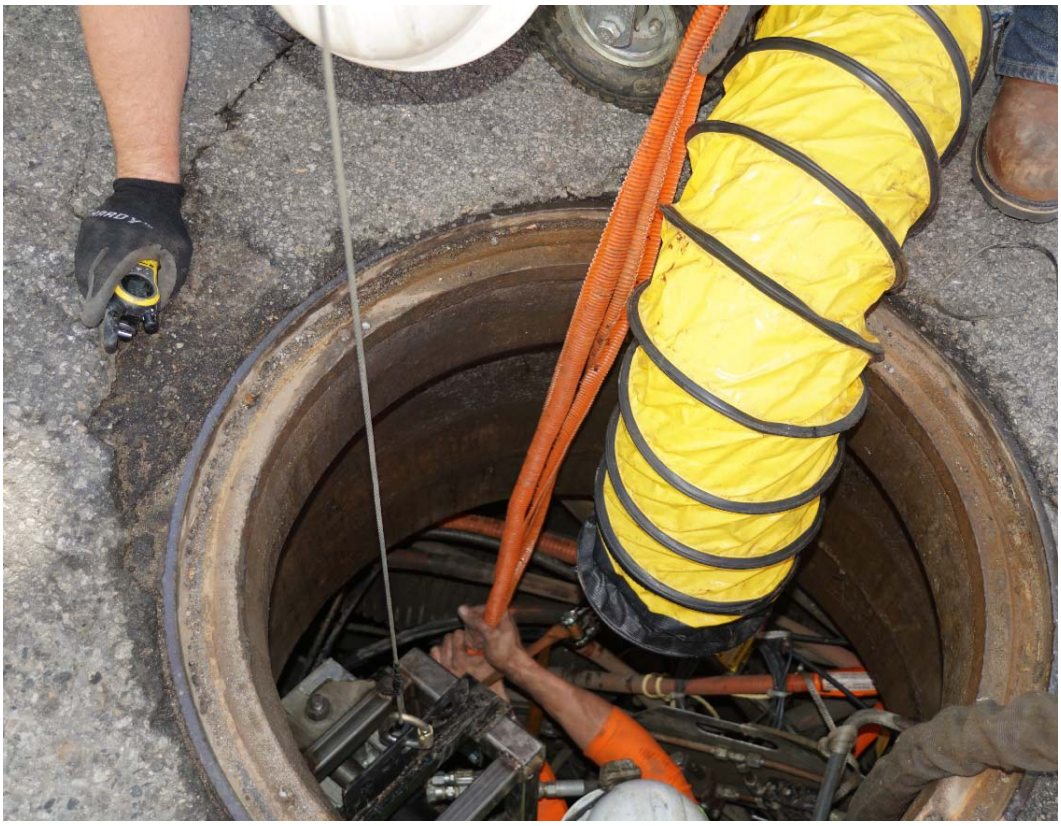
1.33.2. Conducts that have three HDPE innerducts removed shall have a minimum of two (2) Maxcell 3-inch, 3-cell, fabric innerducts installed as a replacement.



MaxSpace Recovery process: The three innerducts on the left are to be removed and replaced.

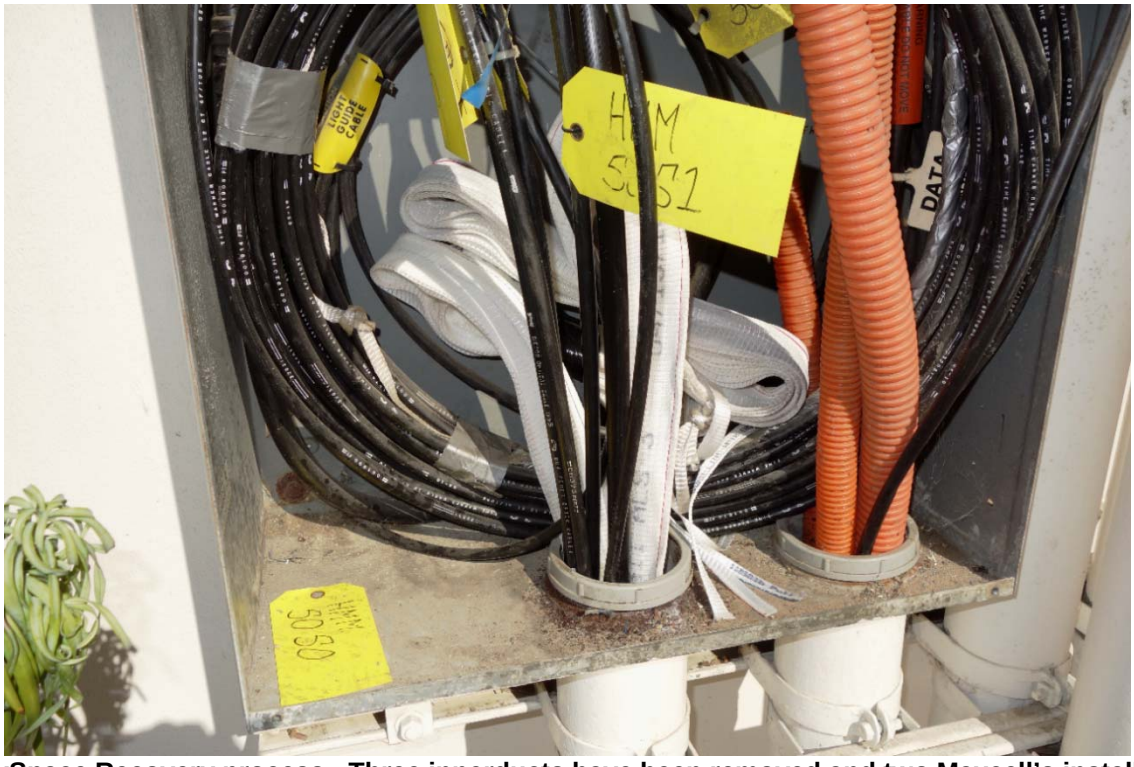
MaxSpace Recovery process: Setting up for the process.

MaxSpace Recovery process: The first innerduct is being split and pulled out of the ductbank.



MaxSpace Recovery process: The second innerduct is being split and pulled out of the MH.

MaxSpace Recovery process: The fabric innerduct is being prepared to replace the HDPE.



MaxSpace Recovery process: Three innerducts have been removed and two Maxcell's installed.

1.34. BD > OSP > PATHWAYS > AERIAL PLANT

1.34.1. Aerial pathways and cable installations are allowed for temporary installations to project trailers and for temporary facilities with LAWA pre-approval.

A temporary pole set up for a project trailer is shown.

1.34.2. Aerial pathways and cable installations may be allowed for permanent backbone installations with LAWA pre-approval when underground options are not available.

1.34.3. Poles shall be of sufficient strength and size to withstand wind loading and maintain vertical clearances using guy wires shall be used to offset transverse loading.

1.34.4. A 12' pole shall have six (6) feet buried below ground. A 15' pole shall have seven (7) feet buried below ground. An 18' pole shall have eight (8) feet buried below ground .

1.34.5. All Pole installations shall meet all local codes and requirements.

Splice case on aerial pole for comm.

1.35. BD > OSP > PATHWAYS > ANTENNAS

1.35.1. All roof-mount antennas shall require LAWA's pre-approval.

1.35.2. Antenna bottoms shall be a minimum of six (6) feet above the deck where people walk.

1.35.3. Short antennas may be mounted to non-penetrating rectangular-base surface roof mounts and are secured with concrete blocks used for ballast. Surface roof mounts shall be set on a protective pad designed for the purpose and not on the bare roof. The ballast weight requirement shall be in accordance with manufacturer recommendations.

A sample small non-penetrating rectangular-base surface roof mount is shown.

A sample large non-penetrating rectangular-base surface roof mount is shown.

1.35.4. Roof penetrations shall be avoided for cable entries.

1.35.5. Roof penetrations shall use proper sealant for prevent leaks.

1.35.6. Roof-mount bases shall be wide enough to accommodate the entire concrete ballast so that blocks do not damage the roofing materials.

1.35.7. Roof-mount cables shall route to IT rooms through weather heads installed on 2-inch conduits against the building wall if possible.

A sample of weather heads are shown.

1.35.8. Roof-mount antenna cables shall be neatly and professionally routed and securely mounted.

1.35.9. Roof-mount antenna cables may also be mounted on galvanized strut on the inside of parapet walls – if pre-approved by LAWA.

Parapet wall antenna and conduit pathway.

1.35.10. Roof-mount antenna cables shall not lie directly on the roof.

1.35.11. Wall-mounted antenna mounts and brackets to support masts and pipes shall be galvanized high strength steel and can be specific brackets or galvanized strut.

1.35.12. Wall-mounted antenna cables shall stand off-the-wall and be supported.

1.35.13. Wall-mounts shall be anchored into building structural members.

Wall-mounted antenna are shown.

Wall-mount antenna and conduit pathway.

1.35.14. Pole-mounted antennas located in areas subject to damage like parking lots shall have conduit installed up the pole to protect the cable.

1.35.15. Antenna cables shall be rated for outdoor use in full sun.

1.35.16. All antennas shall be labeled as to owner, date installed, purpose, and contact number.

Roof-mounted antenna higher than 6-feet.

Asphalt support conduit pathway.

1.36. BD > OSP > PATHWAYS > ANTENNA TOWERS

1.36.1. Antenna towers shall be constructed high enough for line-of-sight wireless connectivity to the next antenna.

1.36.2. Antenna towers shall be triangular, self-supporting, galvanized structures without the need for guying.

Triangular antenna tower with ladder and safety fall arrest.

1.36.3. Antenna towers shall have redundant FAA-certified red flashing obstruction lights.

An antenna tower with two FAA-certified red flashing obstruction lights on the top.

1.36.4. Antenna towers shall meet the ANSI/TIA 222-G (2014) Structural Standard for Steel Antenna Towers and Antenna.

1.36.5. Towers shall have a ladder and fall arrest system.

1.36.6. An antenna-tower safety class and two safety harnesses shall be procured by the project.

1.36.7. Supporting Structures and shall be accompanied by a structural analysis report.

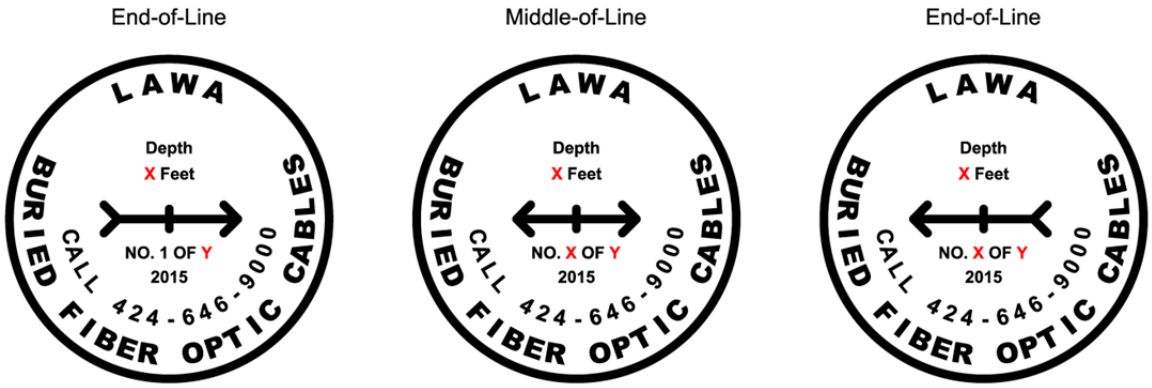
Wall-mounted antenna higher than 6-feet.

Cable protected up antenna pole.

Outdoor rated antenna cable.

1.37. BD > OSP > PATHWAYS > MONUMENT SURVEY MARKERS

1.37.1. Three different (see diagram below) monument survey markers shall be used to identify underground conduit and cables that are not concrete-encased.



Monument survey marker to identify LAWA underground cables.

1.37.2. Markers shall be epoxied in holes drilled in concrete or asphalt for the monuments.

1.37.3. Monument survey markers shall be placed above the conduit/cable and on both sides of driveways and taxiways, and in line not to exceed 100 feet.

1.37.4. Arrows on the markers shall be oriented to show the true direction of the conduit/cable run.

1.37.5. Markers shall be placed and each end – (origin and destination and in between.

Monument survey marker shown from side view.

1.38. BD > OSP > CABLE > COPPER > CATEGORY 3

1.38.1. New passenger terminals shall install a minimum of 100-pair of UL listed CAT 3 outdoor rated backbone "house" cable Riser or plenum rated cables into each IT Room.

1.38.2. CAT 3 backbone cable shall be capable of handling bandwidths up to 16 Megahertz.

1.39. BD > OSP > CABLE > COPPER > PROTECTORS

1.39.1. All CAT 3 copper cables entering buildings from outdoors, shall be protected by cable protectors.

Protector blocks for a 25-pair Cat 3 copper cable.

Protector blocks for a 1600-pair Cat 3 copper cable.

Entrance facility cable protectors.

1.40. BD > OSP > CABLE > FIBER

1.40.1. Singlemode fiber shall be installed. Multimode fiber shall not be installed.

1.40.2. All outside plant fiber optic cables shall use Corning SMF28e+ glass with bend-insensitive additive code "H" (aka Ultra) and Corning loose tube Altos jacketing. See Appendix N for exceptions.

1.40.3. Corning Altos fiber jacketing shall be used for all underground installations entering a facility less than 50-feet.

1.40.4. Corning Freedm fiber jacketing shall be used for all underground installations that require to enter a facility more than 50-feet. See Appendix N for exceptions.

Corning OSP indoor/outdoor Freedm Ultra fiber with bend-insensitive additive is shown.

1.40.5. The minimum fiber count from the MPOE of one facility to the MPOE of another facility shall be 144-strands of singlemode fiber.

1.40.6. The minimum fiber count around the perimeter of an airport shall be 288-strands of singlemode fiber with 24-strands dropped off at each perimeter pedestal clockwise and counter-clockwise. Fiber count shall be increased accordingly as the number of pedestals increase. Cable shall have an outer diameter of 1-inch or less to fit in the Maxcell innerduct.

1.40.7. The minimum fiber count from an MPOE to an individual outdoor Telecom Enclosure (TE) shall be 12-strands of singlemode fiber. If the 12-strands does not include 50% growth, the fiber count shall be increase to 24-strands or accordingly.

1.40.8. Outside plant shall include 50 feet of fiber cable slack in every other maintenance hole.

1.41. BD > OSP > CABLE > DIRECT BURY

1.41.1. Cables shall not be directly buried at LAWA airports.

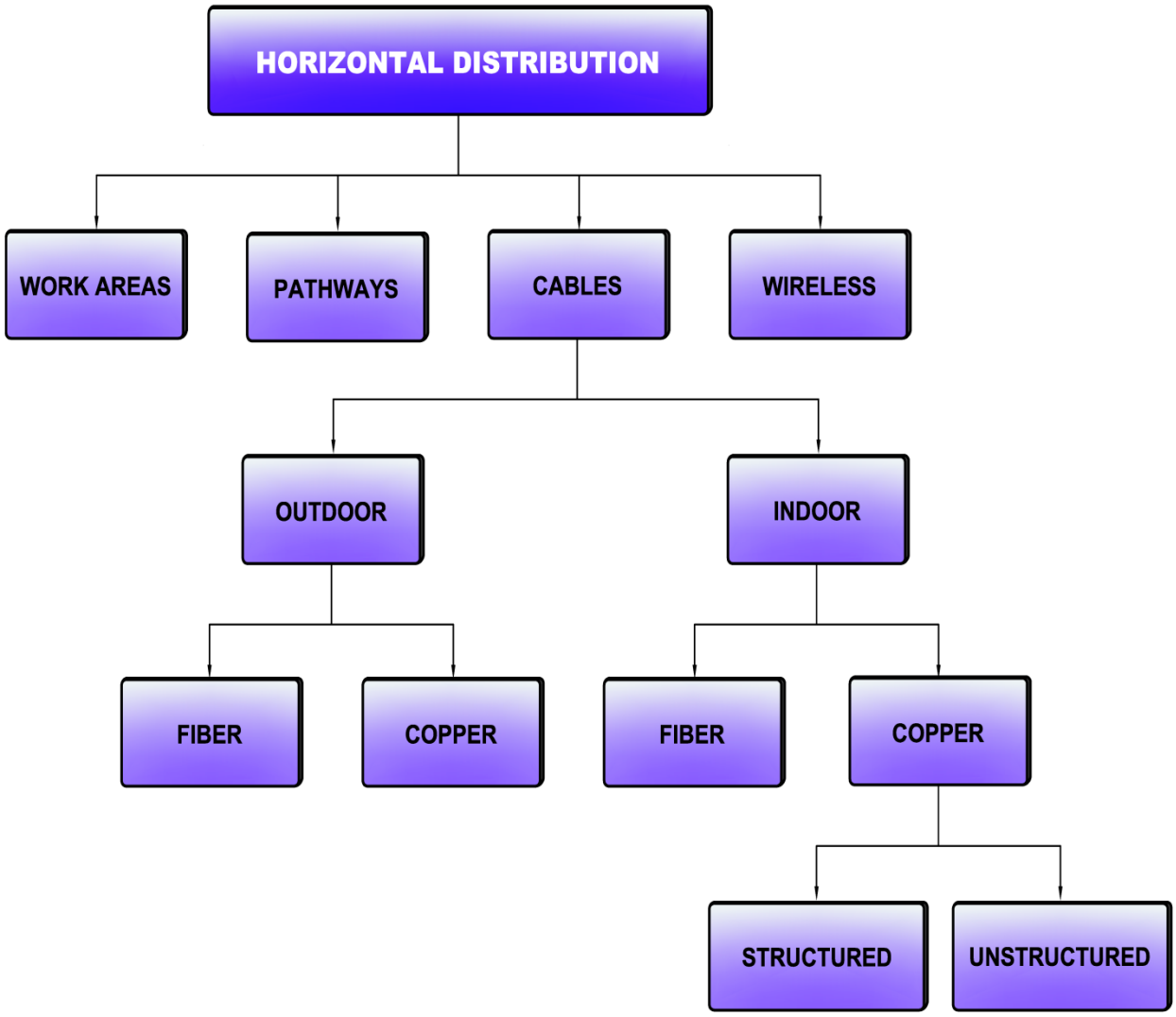
The finding of direct buried cable has unintended consequences when accidently discovered.

2. HORIZONTAL DISTRIBUTION (HD)

2.1. HD > GENERAL

2.1.1. **Horizontal Distribution** is the local cabling that connects work areas to the local IT room. The local IT Room only serves specific work areas in a building. Horizontal Distribution allows End-Users and system equipment to be connected to the Network.

2.1.2. Horizontal Distribution connects Work Areas to Local IT Rooms.



Horizontal Distribution is comprised of the above components.

2.2. HD > SPACE > WORK AREAS

2.2.1. Work areas shall have a sufficient number of WAO's conveniently located to serve the needs of the space plus 50% spare.

2.2.2. Work area cables shall be installed without splices.

2.2.3. Work area cables may be installed directly to equipment (like wireless access point and cameras) without terminating in a WAO.

2.2.4. Work Area Outlet boxes shall be a minimum of 4S deep (4-inch square), flush-mounted, and located adjacent to a power receptacle (if possible). Work area outlet boxes shall be fed one (1) 1" to 1.5" conduit depending upon the number of cable required to the outlet.

2.2.5. Work Area Outlets shall be mounted at the same height as the existing convenience outlets, unless required to meet ADA requirements.

2.2.6. Work area cables shall be calculated as need plus one (1) spare cable for future use.

2.2.7. For cubicle work areas where the workstation plugs into the VoIP phone, and network printers and scanners are used, two (2) cables shall be installed.

2.2.8. For cubicle work areas where the workstation does not plug into the VoIP phone, and network printers and scanners are used, three (3) cables shall be installed.

2.2.9. For high density usage like ticket counters, gate counters, and boarding pass podiums, a minimum of three (3) cables shall be installed unless more are required due to equipment density.

2.2.10. Horizontal cable color shall be orange or blue.

2.2.11. Work area outlet inserts shall be orange in color.

2.2.12. Horizontal cables may land in a mid-span consolidation point or a MUTOA – after obtaining written approval from LAWA.

2.2.13. Work area outlets shall be neatly and professionally labeled at the outlet using a label maker, on the front of the wall plate and in the IT room/closet.

2.2.14. Work area outlets shall meet or exceed the standards-based performance criteria for the cable type installed, i.e. CAT 6/6A.

2.2.15. Copper patch cords shall not exceed 16.5 feet in length.

2.2.16. Horizontal cables shall be tested and certified to industry standards.

2.2.17. Cubicle islands shall be fed with cable whips that appear on columns.

2.2.18. Cubicles islands that cannot be fed with cable whips shall be fed with "power poles" that have metal dividers between comm. and power.

2.2.19. Placement of WOA's in offices is dependent upon the furniture layout and must be consulted prior to – otherwise additional cables will have to run to compensate for changes. Offices are typically cabled on the side-wall that the furniture is adjacent to. Some offices may require four (4) WOA's – desktop work station, large A/V monitor, conference phone on side table, and wireless access point in the ceiling.

2.2.20. Large monitors (e.g. visual paging) within the passenger terminals require five (5) cables to the WAO – Large monitor LAN, RS232 control, iBoot remote monitor reboot, small camera to remotely view content, and a wireless A/P.

WAO's shown with jumpers and split-loom-covered cables.

WAO shown for a cubicle.

WAO shown for U-shaped desk.

2.3. HD > WORK AREAS > CUBICLES

2.3.1. Cubicles located adjacent to walls shall be cabled down the inside of the wall and enter the cubicle island from a black flexible non-metallic tubing – split loom may be used – if acceptable to the AHJ.

2.3.2. Cubicle islands located adjacent to columns shall be cabled down the inside of the column and enter the cubicle island from a black flexible non-metallic tubing – split loom may be used – if acceptable to the AHJ.

Cubicle islands may have cables routed in column housings.

2.3.3. Cubicle islands located on top of raised access floors shall be cabled from under the raised access floor and enter the cubicle island from a black flexible non-metallic tubing – split loom may be used – if acceptable to the AHJ.

2.3.4. Cubicle islands located in the middle of the floor shall be cabled either from telecom/power poles from the ceiling, or from poke-through monuments from the floor below.

2.3.5. Telecom/power poles shall be located within the cubicle island as to be accessible for futures Moves/Adds/Changes.

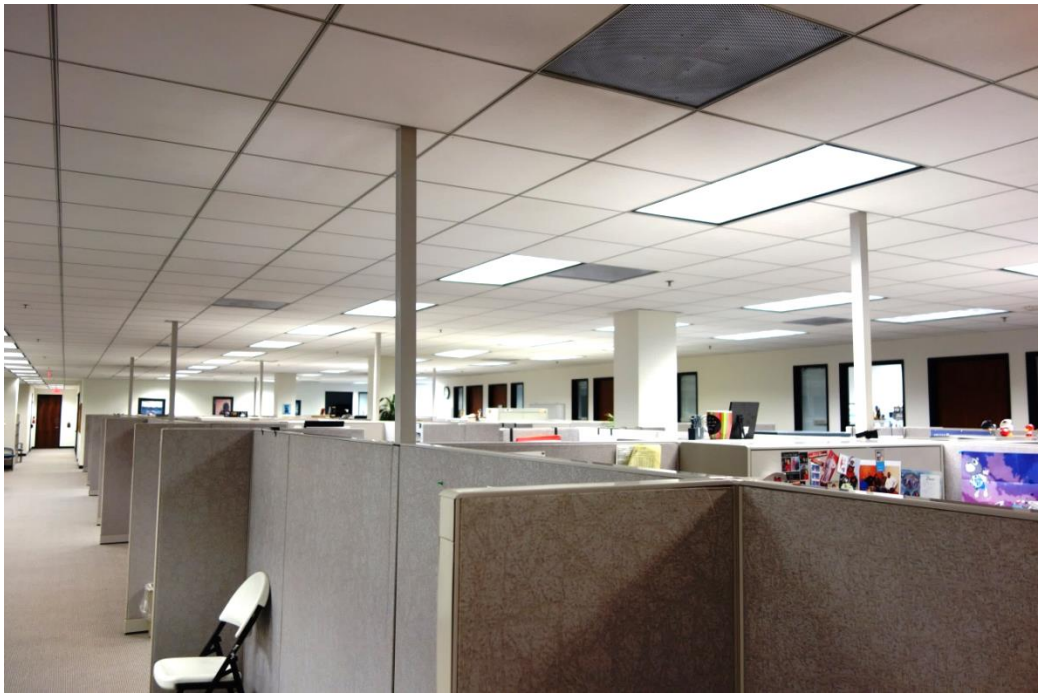
2.3.6. Individual cubicles shall be cabled using two (2) Category 6 cables.

The standard cubicle is fed with two CAT 6 cables.

2.4. HD > WORK AREAS > CUBICLE POWER POLES

2.4.1. Cubicle islands located in the middle of the floor shall be cabled either from telecom/power poles from the ceiling, or from poke-through monuments from the floor below.

2.4.2. Telecom/power poles shall be located within the cubicle island as to be accessible for futures Moves/Adds/Changes.



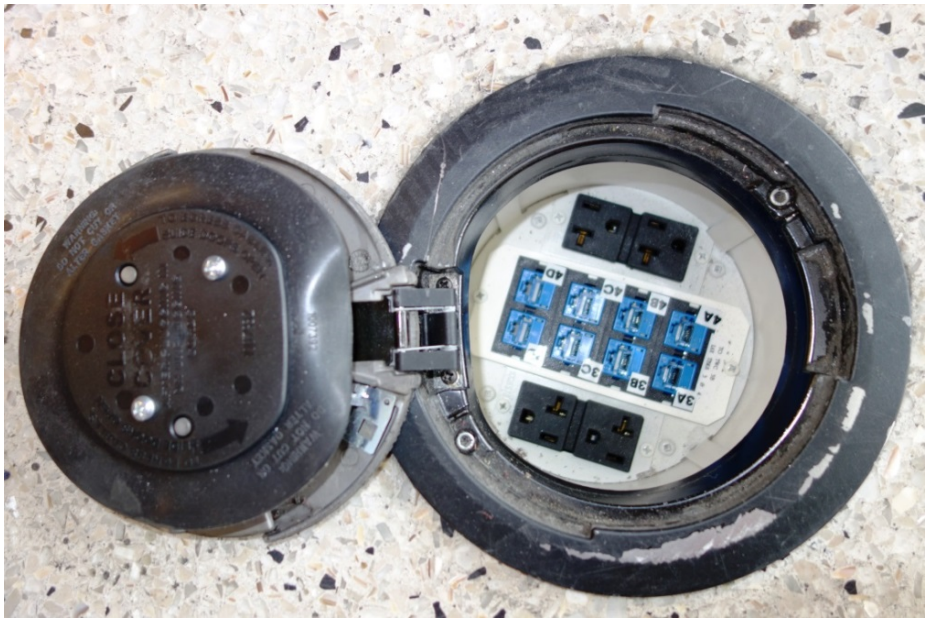
Cubicle islands may be fed from split power/comm. poles.

2.4.3. Telecom/Power poles shall be split to separate power from data cables.

2.4.4. Individual cubicles shall be cabled using two (2) Category 6 cables.

2.5. HD > WORK AREAS > FLOOR MONUMEMTS

2.5.1. Monuments shall contain both data outlets and electrical outlets sized for the required need.



Shown is a floor monument for both power and communications on a terrazzo floor.

2.5.2. Data and power outlets shall be labeled in the monument.

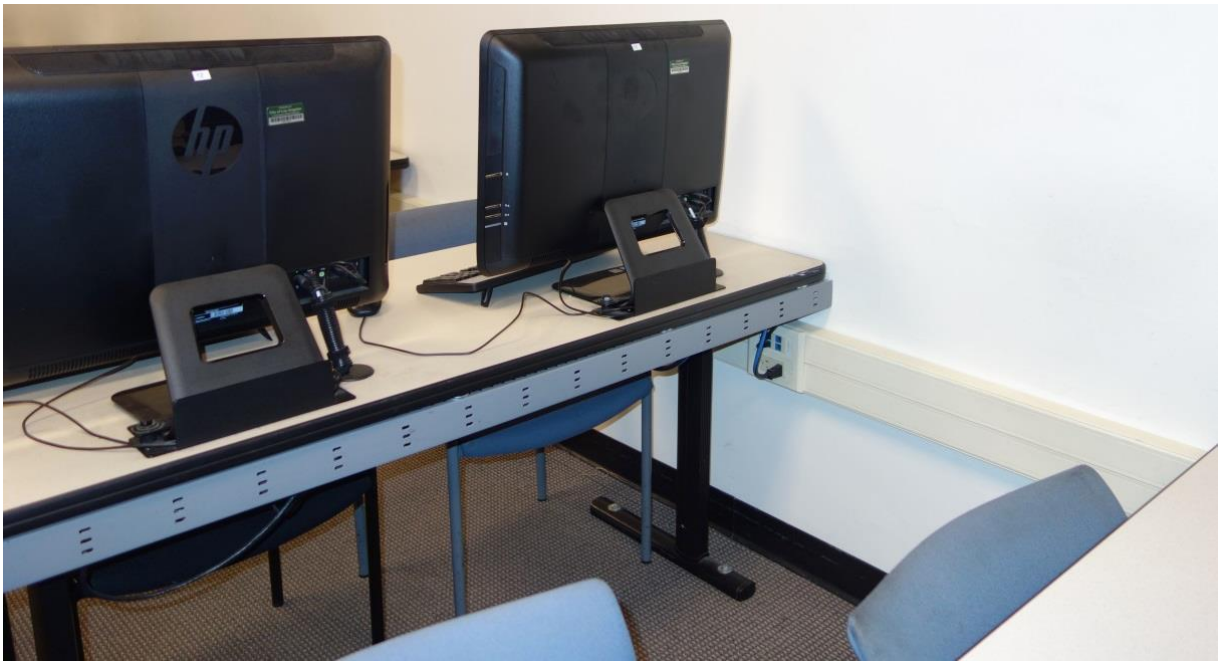
2.5.3. Monument finish shall be brass – unless specified differently by designer.

2.5.4. Poke-Through monuments shall be located away from user's foot reach so that cables and cords do not get damaged.

A floor monument on a carpet tile floor is shown.

2.6. HD > PATHWAYS > SURFACE-MOUNT RACEWAY

2.6.1. Surface-mount raceway is allowed to keep cables managed and neat for areas where Work Area Outlets are too far away.



Sample wall-surface-mount raceway shown.

Surface-mount raceway is split to separate power and comm.

2.7. HD > CABLE > CAT 6 & 6A > CABLE

2.7.1. CAT 6A Structured Cabling Solutions (SCS) shall be installed in all new and renovated passenger terminals unless LAWA IMTG deems otherwise.

2.7.2. A SCS is an industry-standards-based infrastructure where the manufacturer specifies the WAO, patch panel, and cabling components for a complete permanent link. The manufacturer also requires that installers be certified, and that the installation get inspected.

2.7.3. Structured cabling solutions shall be tested, inspected, certified, and have a minimum 20 year warranty.

2.7.4. SCS's shall use CAT 6A cable components with cable that have outside diameters less than **0.285** inches.

2.7.5. Unstructured or Non-structured cabling solutions are installations that use standards-based components but not necessarily specified by a particular manufacturer and typically are not warranted for more than one year.

2.7.6. Test results, certification, and warranty shall be provided to LAWA in PDF format.

2.7.7. Within LAWA office buildings, unstructured cable solutions using CAT 6 cable shall be installed – unless directed otherwise by LAWA IMTG.

2.7.8. CAT 6 cables shall use outside diameters less than **0.26** inches.

2.7.9. See Appendix for Parts List. Some renovations or additions to passenger terminals may have CAT 6 cables installed in place of CAT 6A after approval from LAWA.

Function	Structured	Unstructured
Standards-based Work Area Outlet?	Yes	Yes
Standards-based CAT 6 cable?	Requires LAWA Pre-approval	Yes
Standards-based CAT 6A cable?	Yes	Yes
Standards-based Patch Panel?	Yes	Yes
Installers certified by the specific manufacturer providing the warranty?	Yes	On a Case-by-case Basis
Installation Inspected?	Yes	Yes
Installation Certified with a Standards-based Cable Tester?	Yes	Yes
Minimum 20 year warranty?	Yes	No - 1 Year

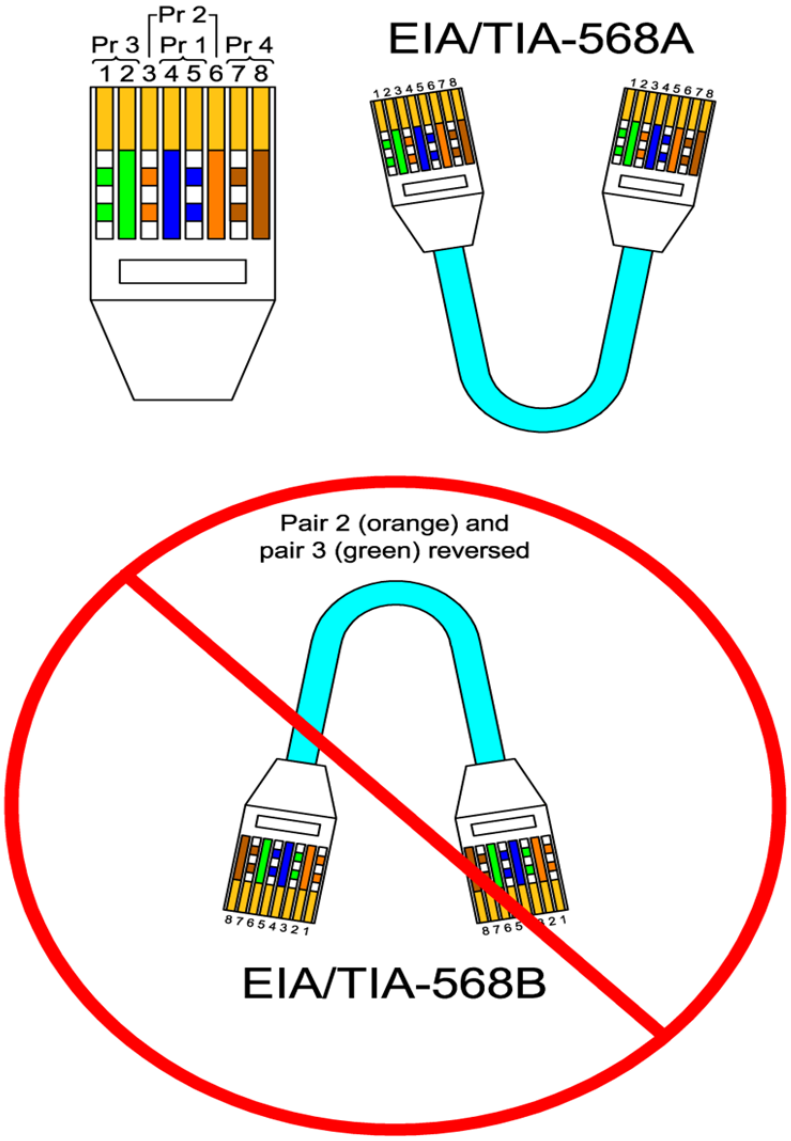
This table lists the requirements of structured versus unstructured cabling solutions.

Legacy CAT 6 cables shown.

Legacy CAT 6A cables shown.

2.8. HD > CABLE > CAT 6 & 6A > TERMINATION

2.8.1. LAWA uses EIA/TIA 568A pinouts for all RJ-45 CAT 6 and CAT 6A connectors.



CAT 6/6A cable shall follow the EIA/TIA-568A wiring standard.

2.8.2. EIA/TIA 568B pinouts shall not be used.

2.8.3. Match existing installations for all existing work.

2.8.4. CAT 6/6A cables shall be supported so that there are no pressure points on the cables at the termination.

2.8.5. CAT 6/6A cables shall maintain wide sweeping bend radii.

2.8.6. CAT 6/6A cables shall have cable slack loops secured to the sides of the cabinet walls.

CAT 6A cable slack loops installed per LAWA standards.

2.9. HD > CABLE > CAT 6 & 6A CABLE MANAGEMENT

2.9.1. All cables shall be neatly and professionally dressed, secured, and labeled. Bend radii exceeding the standards shall be maintained.

2.9.2. All bundles of cables shall be combed and neatly and professionally bundled, dressed, secured with Velcro-type fasteners (not cable ties), and labeled. Bend radii exceeding the standards shall be maintained.

2.9.3. All cables in Cable Tray, Ladder Rack, and Wire Basket shall be combed and neatly and professionally bundled, dressed, secured, and labeled. Cables shall follow parallel lines and wide sweeping bends. Bend radii exceeding the standards shall be maintained.

Cable management combed with sweeping bend radii.

2.9.4. All cables entering patch panels shall be combed and neatly and professionally bundled, dressed, secured, and labeled. Bend radii exceeding the standards shall be maintained.

2.9.5. Patch panels installed in the newer 34-inch wide cabinets shall have cables swept horizontally to the cable management areas in each side of the cabinet. From cabinet centerline, cables left of centerline shall be swept and dressed to the left into the cabinet cable management space, and cables right of centerline shall be swept and dressed to the right into cabinet cable management space.

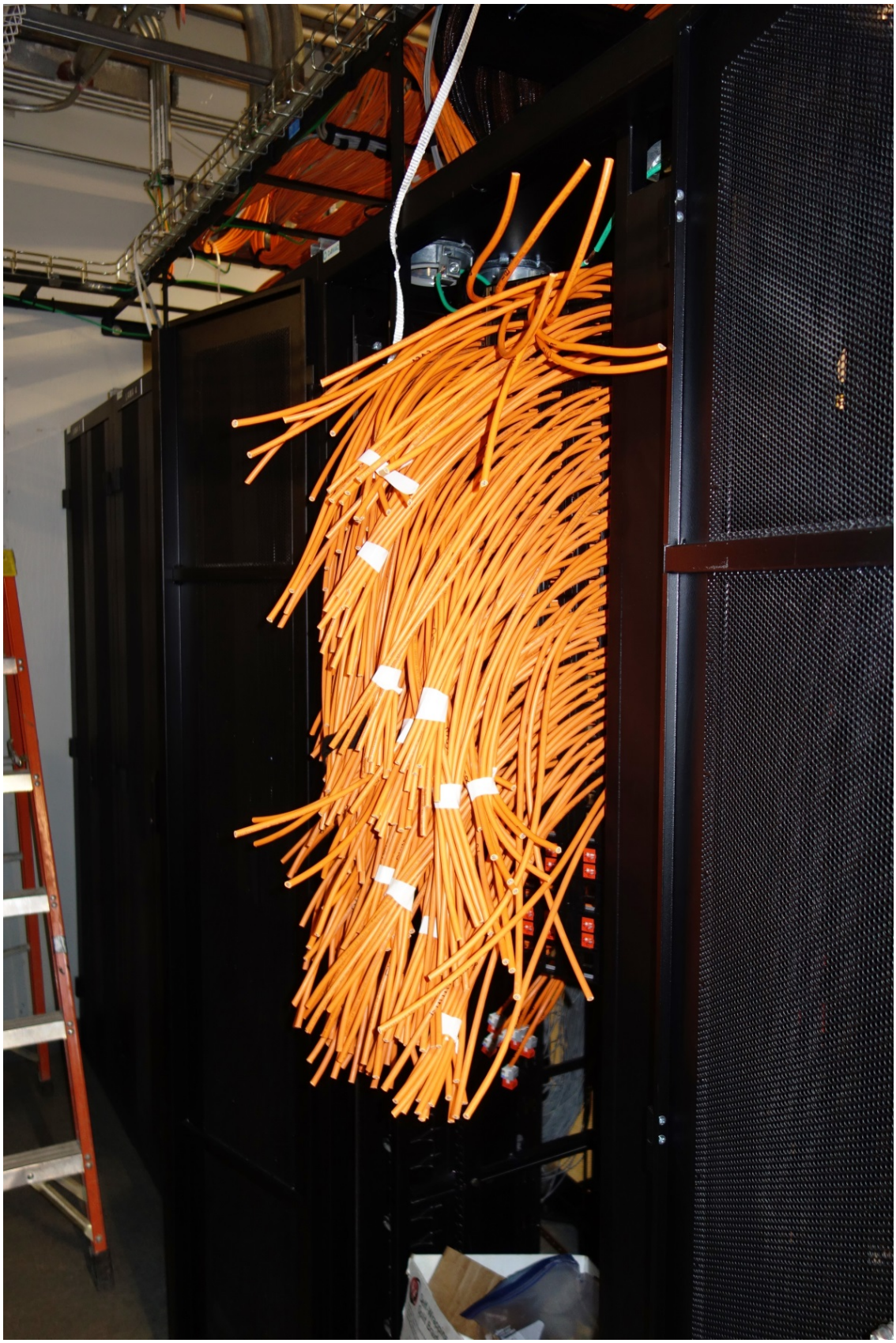
2.9.6. Wall-mount 110 and 66 blocks shall have a 2RU or larger horizontal cable manger with cable retention fingers. Jumpers shall be neatly dressed and bundled to exceed maximum bend radii.

2.9.7. D rings for wall-mount cable management is acceptable.

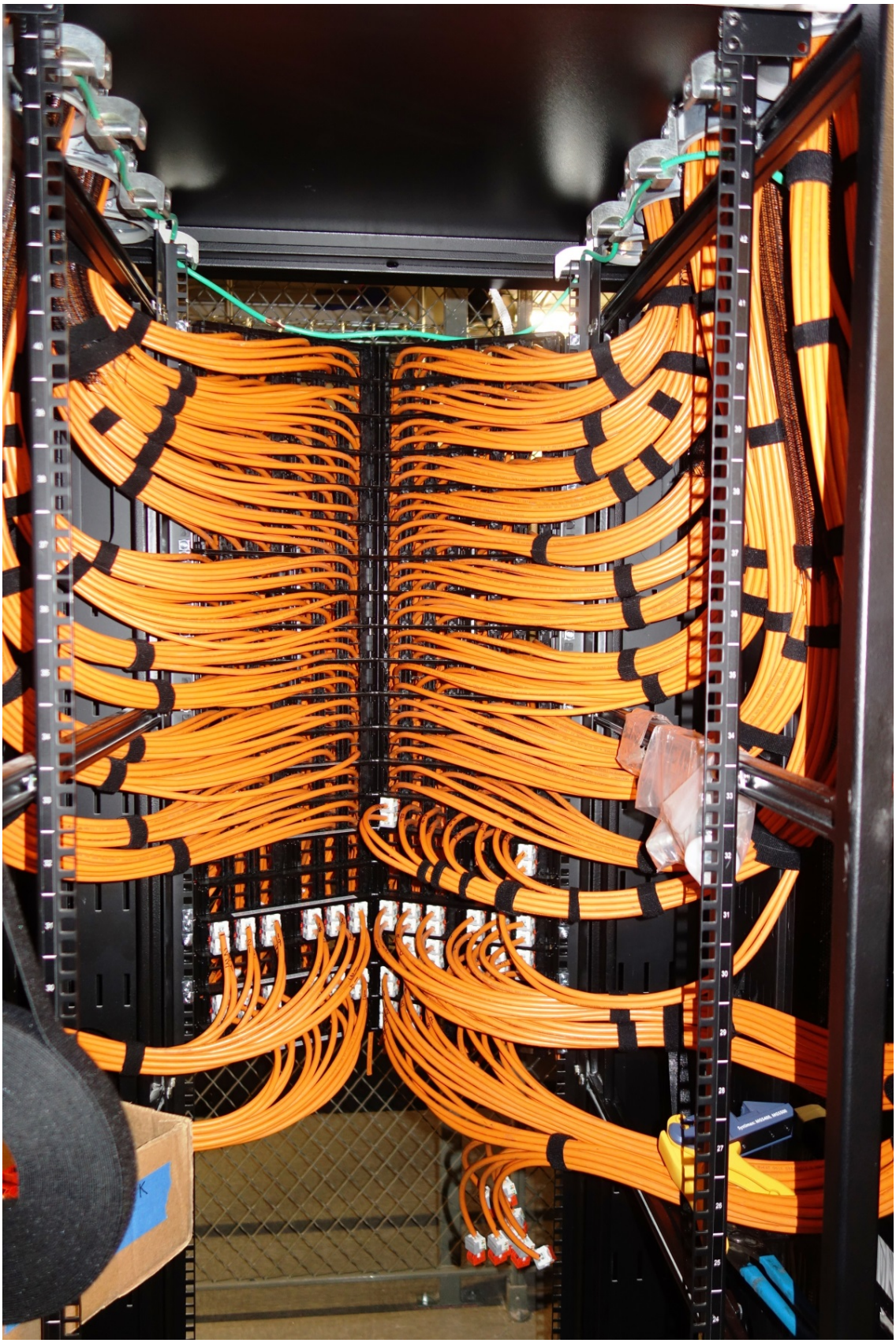
D rings used for cable management on a wall.

2.9.8. For renovations, and In addition to above, legacy patch panels and network switches shall have a 2RU horizontal cable manger with cable retention fingers and a cover below the equipment.

CAT 6A cable terminated per LAWA standards.



CAT 6A cable prepping prior to termination.



A rear-cabinet view of CAT 6A cables terminated per LAWA standards.

A through-cabinet view of CAT 6A cables terminated per LAWA standards.

2.10. HD > CABLE > CAT 6 & 6A > TESTING

2.10.1. All backbone copper cables shall be tested consistent with the cables' rating. For example, Category 3 cable shall be tested with a CAT 3 protocol.

2.10.2. CAT 6A structured cabling solutions shall be tested and certified for CAT 6A performance with a tester designed for ANSI/TIA CAT 6A testing.

2.10.3. The following cable performance parameters shall be tested to TIA-568-B parameters for both the permanent link and the channel with a certifying tester as pertinent to either CAT 6 or CAT 6A cable. Tests shall be conducted using frequencies from 1 MHz to 250 MHz for CAT 6 and from 1 MHz to 500 MHz for CAT 6A cable using a certifying tester that can test for the following.

- Wire Map
- Length
- Propagation Delay
- Delay Skew
- DC Loop Resistance
- DC Resistance Unbalance within a pair
- DC Resistance Unbalance between pairs
- Insertion Loss
- NEXT (Near-End Crosstalk)
- PS NEXT (Power Sum Near-End Crosstalk)
- ACR-N (Attenuation to Crosstalk Ratio Near-End)
- PS ACR-N (Power Sum Attenuation to Crosstalk Ratio Near-End)
- ACR-F (Attenuation to Crosstalk Ratio Far-End)
- PS ACR-F (Power Sum Attenuation to Crosstalk Ratio Far-End)
- Return Loss
- TCL (Transverse Conversion Loss)
- ELTCTL (Equal Level Transverse Conversion Transfer Loss)
- PS ANEXT (Power Sum Alien Near-End Crosstalk)
- Average PS ANEXT (Average Power Sum Alien Near-End Crosstalk)
- PS AACR-F (Power Sum Alien Attenuation to Crosstalk Ratio Far-End)
- Average PS AACR-F (Average Power Sum Alien Attenuation to Crosstalk Ratio Far-End)

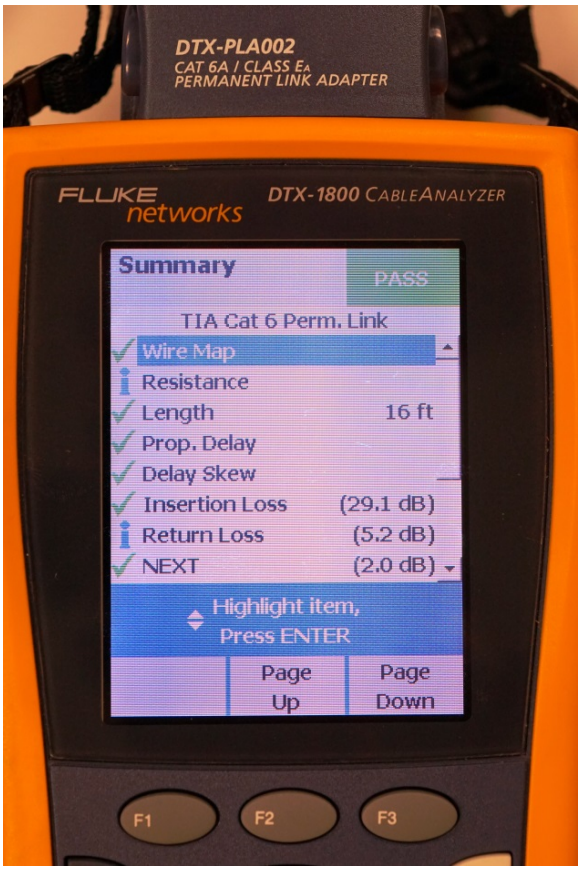
2.11. HD > CABLE > CAT 6 & 6A > TEST EQUIPMENT

2.11.1. Below are suggested manufacturers of LAWA's standard equipment used for testing and troubleshooting CAT 3 copper cables and circuits.

2.11.2. All test equipment shall be calibrated within a year of conducting tests and shall contain the most recent ANSI/TIA testing protocols for certifying the test results.

2.11.3. LAWA reserves the right to see test equipment calibration records anytime requested.

Metallic Time Domain Reflectometer for identifying breaks.



CAT 6/6A tester required for testing and certifying cable installations.

2.12. HD > CABLE > CAT 6 & 6A > CONSOLIDATION POINTS (CP)

2.12.1. Consolidation Points may be used with LAWA's pre-approval.

2.12.2. Ceiling-mount CP's shall be installed in UL-listed and plenum-rated enclosures that fits in a 2' x 2' suspended tile grid if the enclosure opens towards the floor.

2.12.3. CP's mounted in suspended ceiling grids shall be mounted in common corridors.

2.12.4. Above-ceiling CP's mounted in junction boxes shall be readily accessible from a common corridor.

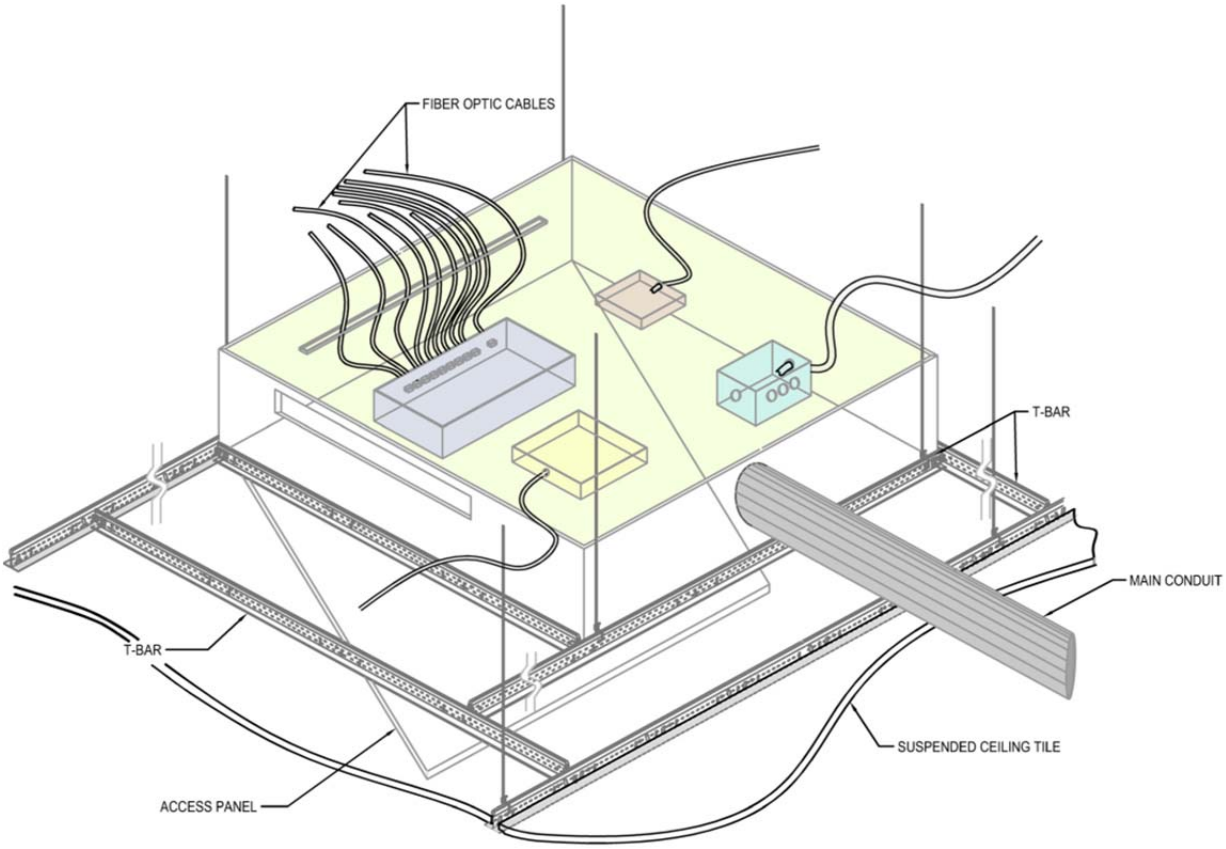
2.12.5. CP's mounted in ceiling grids shall be anchored by 4 wires or if designed to mount on T-bar, shall have a safety tether attached.

2.12.6. In-floor CP's shall be installed in UL-listed and plenum-rated enclosures that fits in a 2' x 2' raised floor grid.

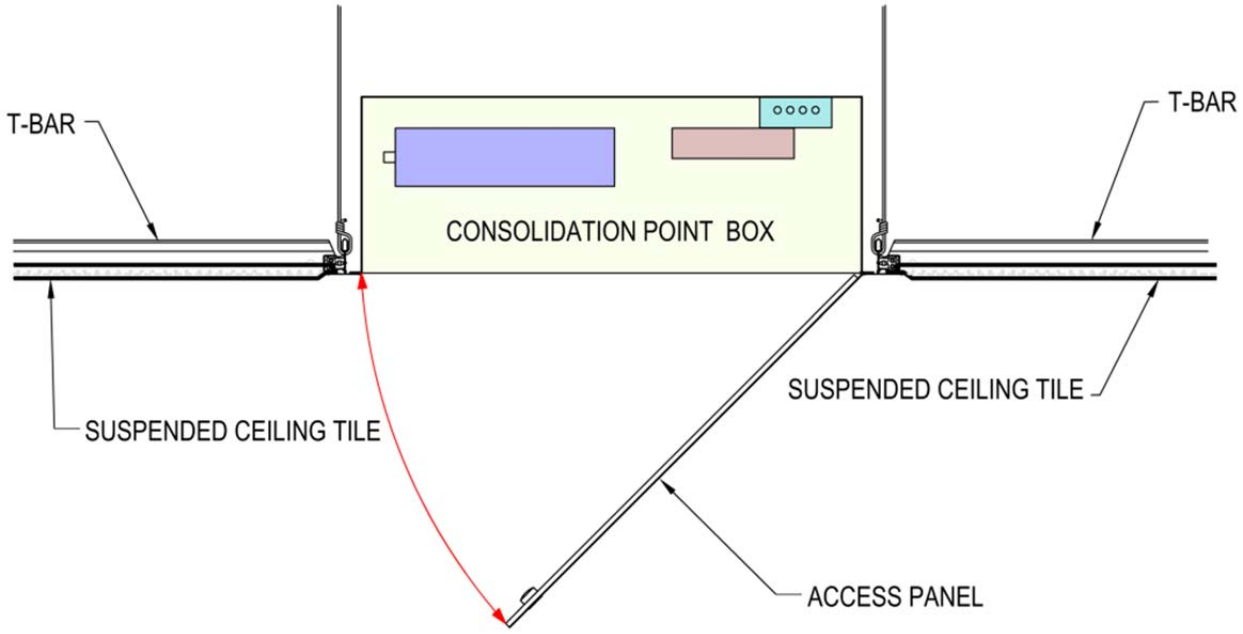
2.12.7. In-column CP's may be installed only if they are accessible and not obstructed by furniture.

2.12.8. CP's within passenger terminals shall have conduit as their pathway.

2.12.9. All CP cable shall be plenum rated – regardless if they are in conduit or not.



A sample Consolidation Point enclosure is shown attached to a suspended ceiling - iso view.



A sample Consolidation Point enclosure is shown attached to a suspended ceiling - side view.

Consolidations Points may be installed in separate junction boxes in the ceiling.

Consolidations Points may be as simple as a WOA in a 4S box.

2.13. HD > TENANTS > LAST MILE

2.13.1. Tenants are required to provide and install any Tenant-required pathway and cabling from their leasehold to the local Tenant Common-Use Wiring Closet (TCWC) or LAWA IT Room (if there is no TCWC available) – unless provided by a project.

Last mile conduit into cabletray from tenant leasehold shown.

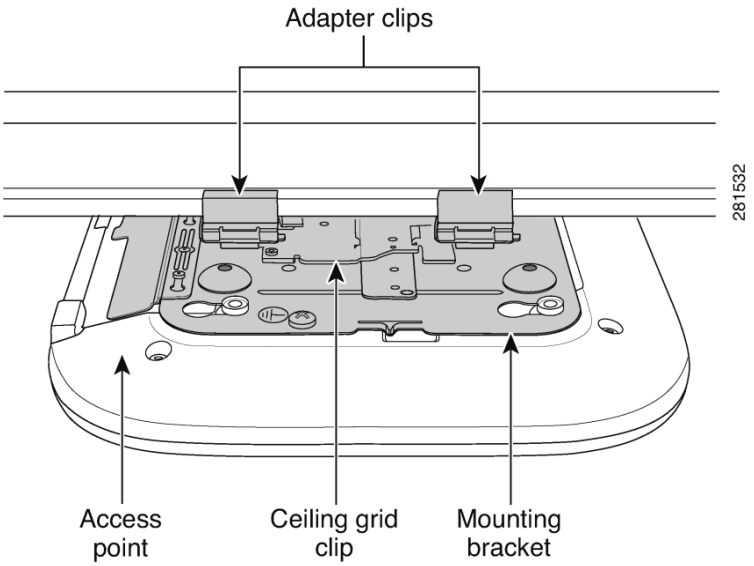
2.14. HD > WIRELESS ACCESS POINTS

2.14.1. A/P's serving maintenance facility staff for building utilities shall be mounted in utility rooms as a second choice after IT Rooms with pre-approval from LAWA.

2.14.2. A/P's shall be as inconspicuous as possible yet accessible for maintenance.

2.14.3. A/Ps shall be mounted on suspended ceiling tile, suspended ceiling T-bar, hard lid, or above ceiling – after obtaining LAWA's pre-approval.

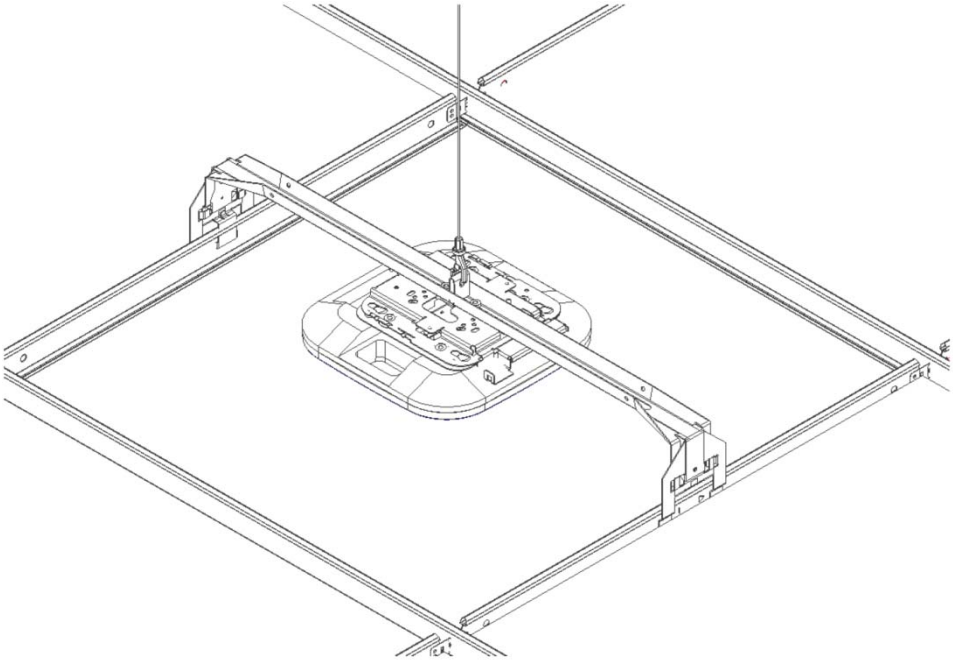
A/P mounted on suspended ceiling T-Bar.



A Cisco direct T-Bar mounting bracket is shown. Courtesy: Cisco.

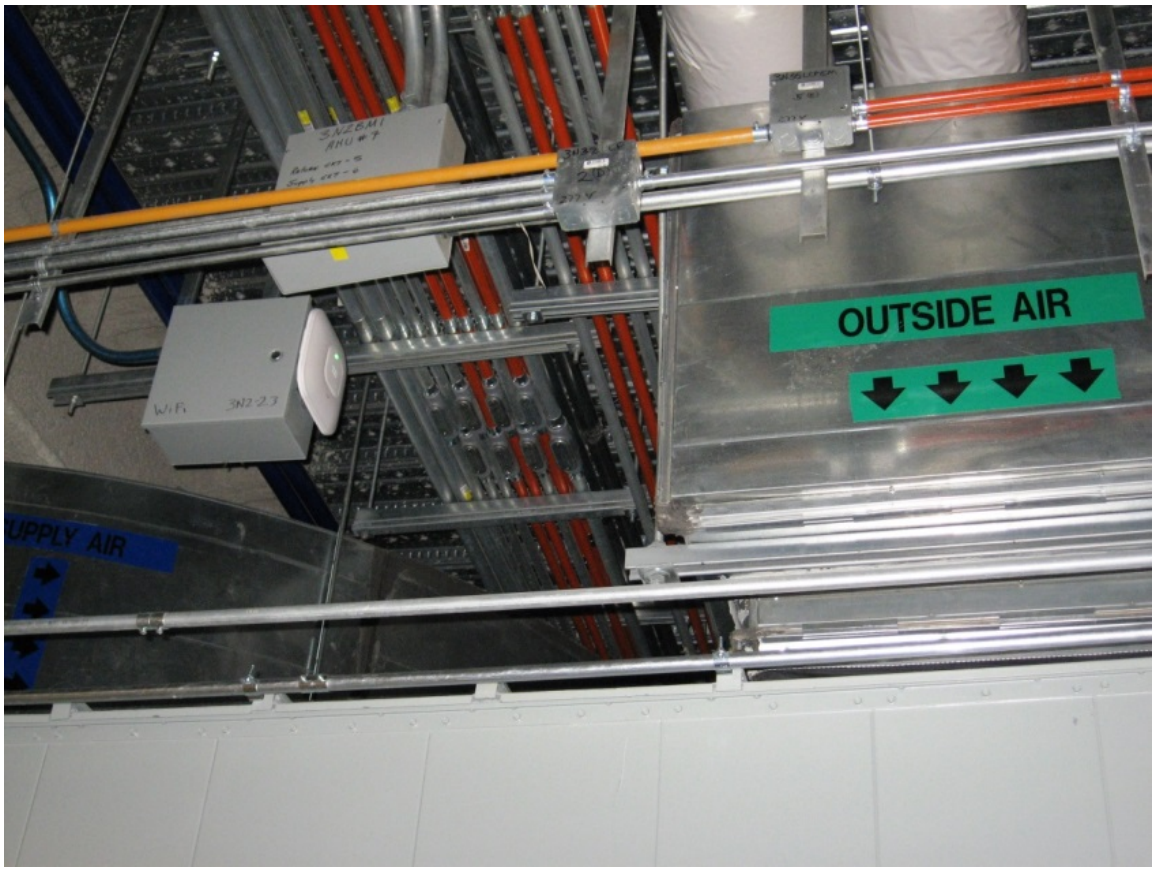
2.14.4. A/P hardware for in--ceiling-tile installations shall not prevent the ceiling tile from being opened normally.

A/P mounted within ceiling tile on the suspended ceiling T-Bar.



An Oberon T-Bar above-ceiling mounting bracket for Cisco A/P's is shown. Courtesy: Oberon.

A/P mounted in an IT Room on the side-wall.



A/P mounted in a j-box above the ceiling in a mechanical room.

2.14.5. A/P pathways within terminals shall be conduit – except within IT Rooms.

2.14.6. If CAT 6A cables are terminated on biscuits, then shall be conduit shall terminat in junction boxes.

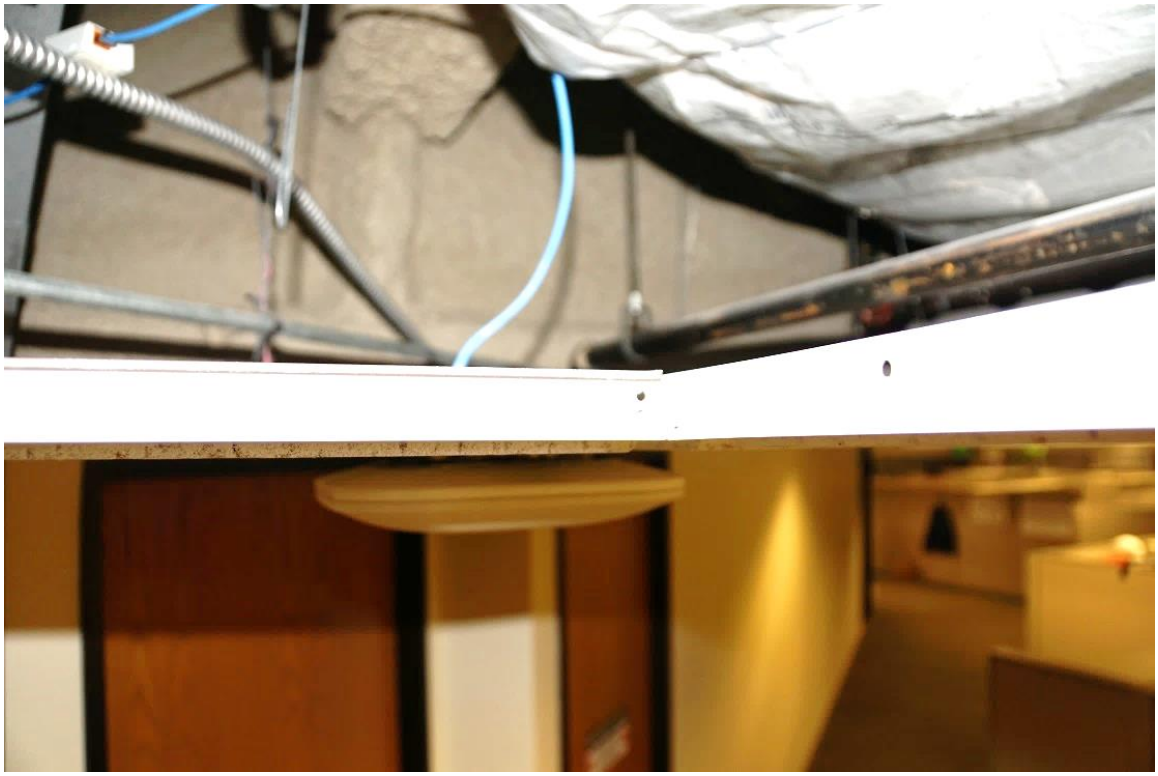
2.14.7. A/P pathways in LAWA office buildings may be conduit or J-Hooks.

2.14.8. A/P cables within terminals shall be fed with plenum-rated (OFNP) Cat 6A cables.

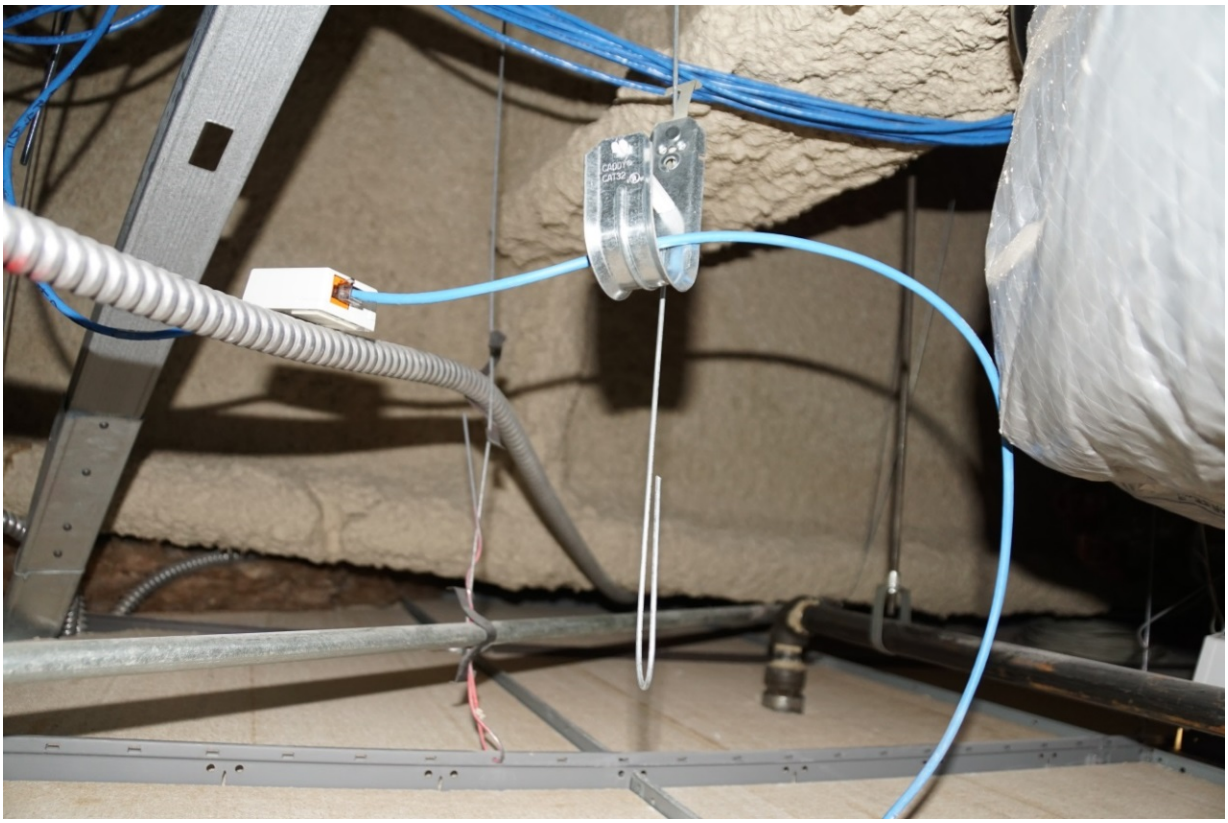
2.14.9. A/P cables within LAWA office buildings may terminate either in a Cat 6/6 biscuit or an RJ-45 plug.

2.14.10. A/P cables in LAWA office buildings shall be fed with plenum-rated (OFNP) Cat 6 cables or as LAWA directs.

2.14.11. A/P cables in LAWA office buildings may terminate on plenum-rated biscuits or RJ-45 plug.



A/P cable fed from above-ceiling through a hole in the ceiling tile.



A/P cable supported by a J-hook terminated in a biscuit before direct A/P connection was allowed.

A legacy A/P mounted in the center of a suspended ceiling tile prior to T-Bar mounting required.

An outdoor A/P is shown mounted on a support column.

A single A/P is shown mounted on an exterior wall.

Multiple A/P's are shown mounted on an exterior wall.

3. COMMON ELEMENTS

3.1. COMMON ELEMENTS INTRODUCTION

3.1.1. Common Elements are those components that may be common to both Backbone and Horizontal Distribution.

3.1.2. Common Element topics are organized alphabetically and include:

- Cable Abandonment
- Cable Management
- Cable Slack
- CAT 3 Test Equipment
- CAT 3 Testing
- Fiber Circuits
- Fiber Connectors
- Fiber Cutovers
- Fiber Patch Panels - Rack-Mount
- Fiber Patch Panels - Wall-Mount
- Fiber Splicing
- Fiber Test Equipment
- Fiber Testing
- Splice Cases

3.2. COMMON ELEMENTS > CABLE ABANDONMENT

3.2.1. All IT construction that required demolition of existing cables shall remove cables from the premise and not abandon cables in place.

Cut cables shall not be abandoned in place.

3.3. COMMON ELEMENTS > CABLE MANAGEMENT

3.3.1. Slack fiber cable shall not be coiled up and stored within the patch panel. See the Cable Slack Section.

3.3.2. Fiber optic jumpers within fiber patch panels shall not be longer than three (3) feet.

3.3.3. Fiber optic jumpers between patch panels and/or equipment shall not have more than three (3) feet of jumper within the patch panel.

3.3.4. Fiber jumpers shall be labeled according to the Labeling Section.

3.3.5. Splice trays shall be stacked and secured - as designed for the respective patch panel.

Splice trays are stacked, jumpers are labeled and less than 3 feet long.

3.4. COMMON ELEMENTS > CABLE SLACK

3.4.1. All cables entering MPOE's and IT Rooms shall have a minimum of twenty-five (25) feet of cable neatly dressed and secured.

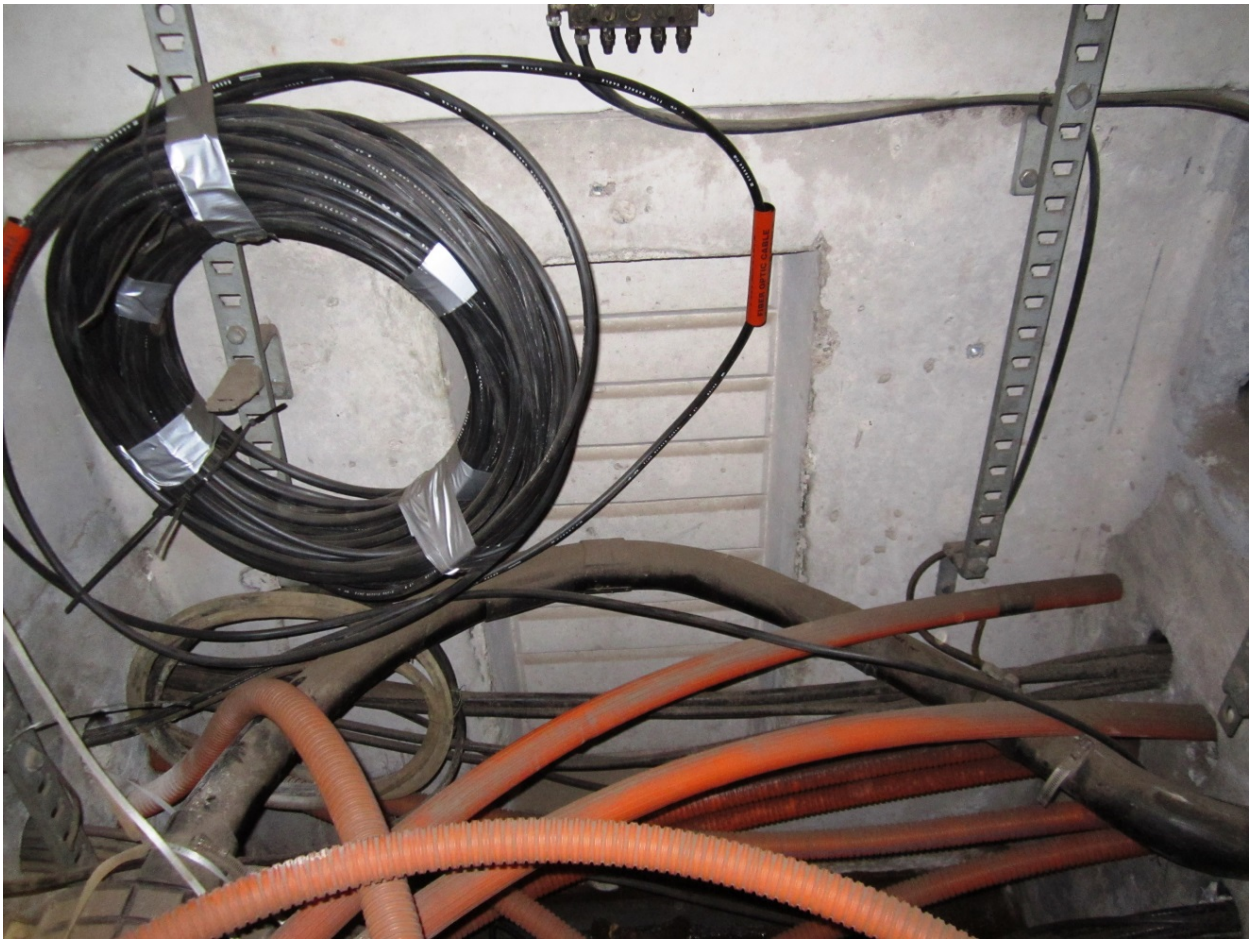
3.4.2. There are four methods for storing cable slack loops.

- Coiled within a junction box in the ceiling within 10 feet of the IT Room
- Underneath the ladder rack held in placed with heavy duty Velco-type material
- Coiled around the inside cabinet perimeter wall of the cabinet that it is serving
- Coiled on a second level of ladder rack installed specifically for cable slack loops.

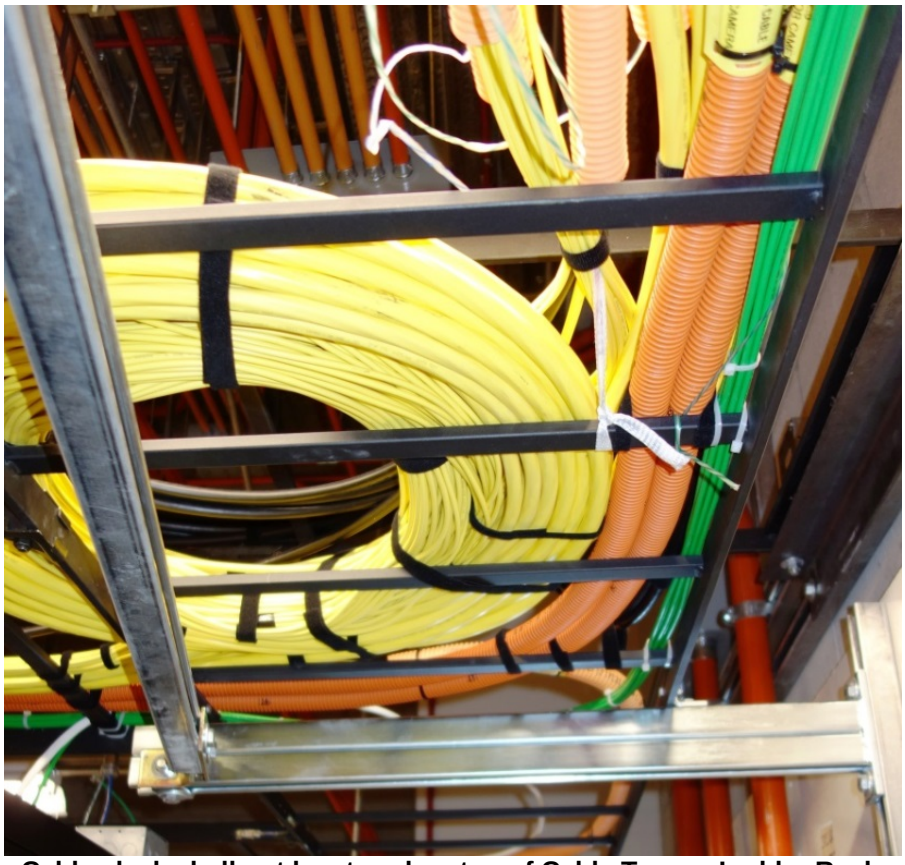
3.4.3. Cable slack loops shall not be coiled and stored on top of the Ladder Rack.

3.4.4. Cable slack loops shall not coil around other cables or objects that will inhibit the ability to uncoil the slack loop when it is needed.

3.4.5. All cable slack loops shall be labeled according to the labeling Standard.

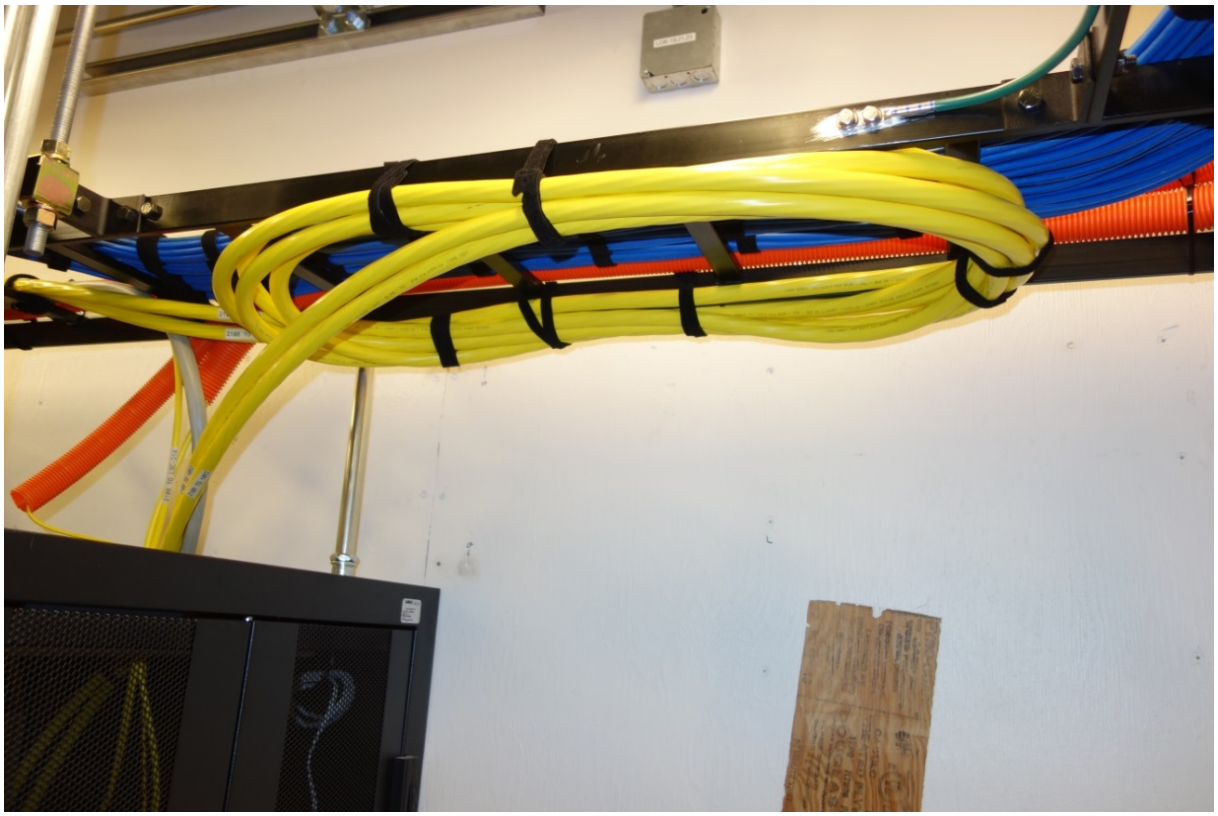


Cable slack loop in a maintenance hole supported on cable rack.



Cable slack shall not be stored on top of Cable Tray or Ladder Rack

Cable slack shall not be stored on top of Cable Tray or Ladder Rack.



One approved method of storing cable slack loop is under the Ladder Rack or Cable Tray.

One approved method of storing cable slack loop is to build a 2nd tier Ladder Rack.

3.4.6. All cable slack loops shall be labeled according to the labeling Standard.

3.4.7. All interior wall-mount fiber patch panels shall have slack loops installed on the wall behind the patch panel. All wall-mount patch panels shall be stood of the wall to allow for slack loops.

3.4.8. Wall-mounted patch panels shall have cable slack loops coiled up behind patch panels.

3.4.9. Junction boxes used for slack loops shall have backboards for securing cable.

If placed within a cabinet, cable slack shall go around the inside perimeter, not coiled up.

Cable slack shall be coiled up behind wall-mount patch panels.

3.5. COMMON ELEMENTS > CAT3 > TEST EQUIPMENT

3.5.1. Below are suggested manufacturers of LAWA's standard equipment used for testing and troubleshooting CAT 3 copper cables and circuits.

3.5.2. All test equipment shall be calibrated within a year of conducting tests and shall contain the most recent ANSI/TIA testing protocols for certifying the test results.

3.5.3. LAWA reserves the right to see test equipment calibration records anytime requested.

Tone generator and probe are used for identifying and troubleshooting copper.

Copper continuity cable tester.

DSL circuit tester for troubleshooting.

T-1 circuit tester for testing and troubleshooting.

3.6. COMMON ELEMENTS > FIBER CIRCUITS

3.6.1. All project designers and projects are responsible for ensuring that all required surveys to identify, locate, demolish, or install all components of circuits are completed by the design or the project contractor.

3.6.2. All projects are responsible for creating the fiber optic circuits required for the project.

3.6.3. All projects are responsible for providing and installing all fiber cable, equipment, and jumpers necessary to create the required fiber circuits.

3.6.4. All projects are responsible for entering all fiber optic backbone data into the LAWA-provided WireCAd Excel Backbone spreadsheet.

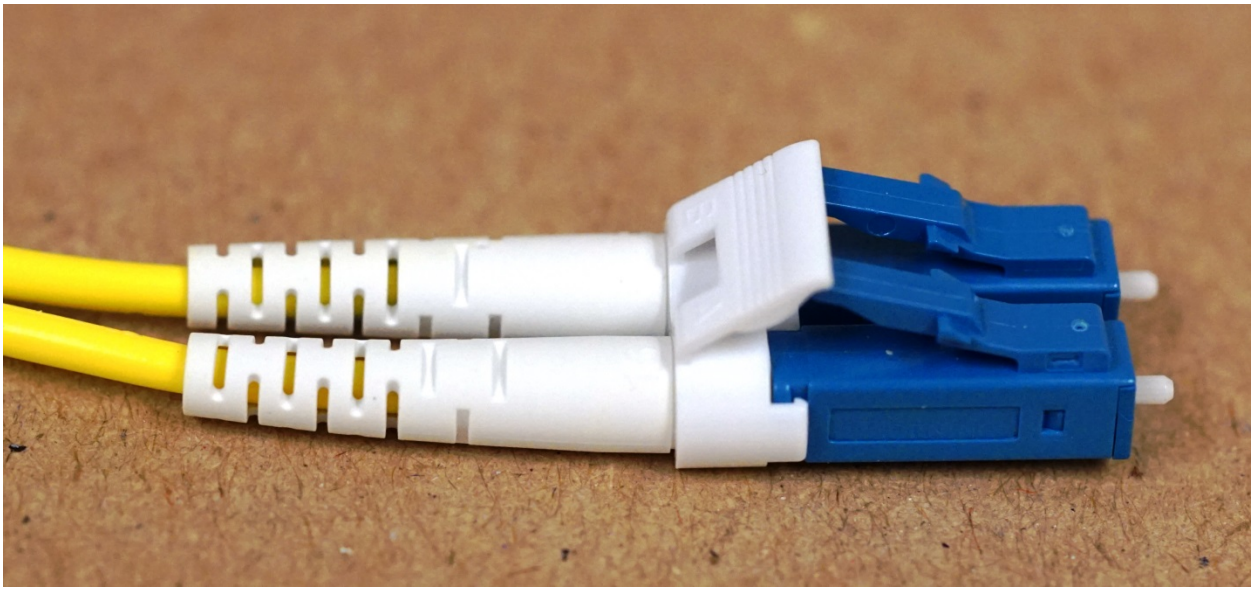
3.6.5. All projects are responsible for entering all fiber optic circuit data into the LAWA-provided WireCAd Excel circuit spreadsheet.

3.6.6. All projects are responsible for providing the verification services of HEI Enterprises to ensure that the contractor-entered backbone and circuit data is error-free and importable into the LAWA WireCAD database. See the WireCAD Section for spreadsheets.

3.7. COMMON ELEMENTS > FIBER CONNECTORS

3.7.1. LC-UPC (Lucent Connector - Ultra Physical Contact) double-density connectors shall be used.

3.7.2. For renovations, where there are cases of legacy fiber cutovers, connectors shall be matched if there are existing jumpers connected, otherwise LC-UPC shall be used.



A sample of the current LAWA-required LC-UPC connector is shown.

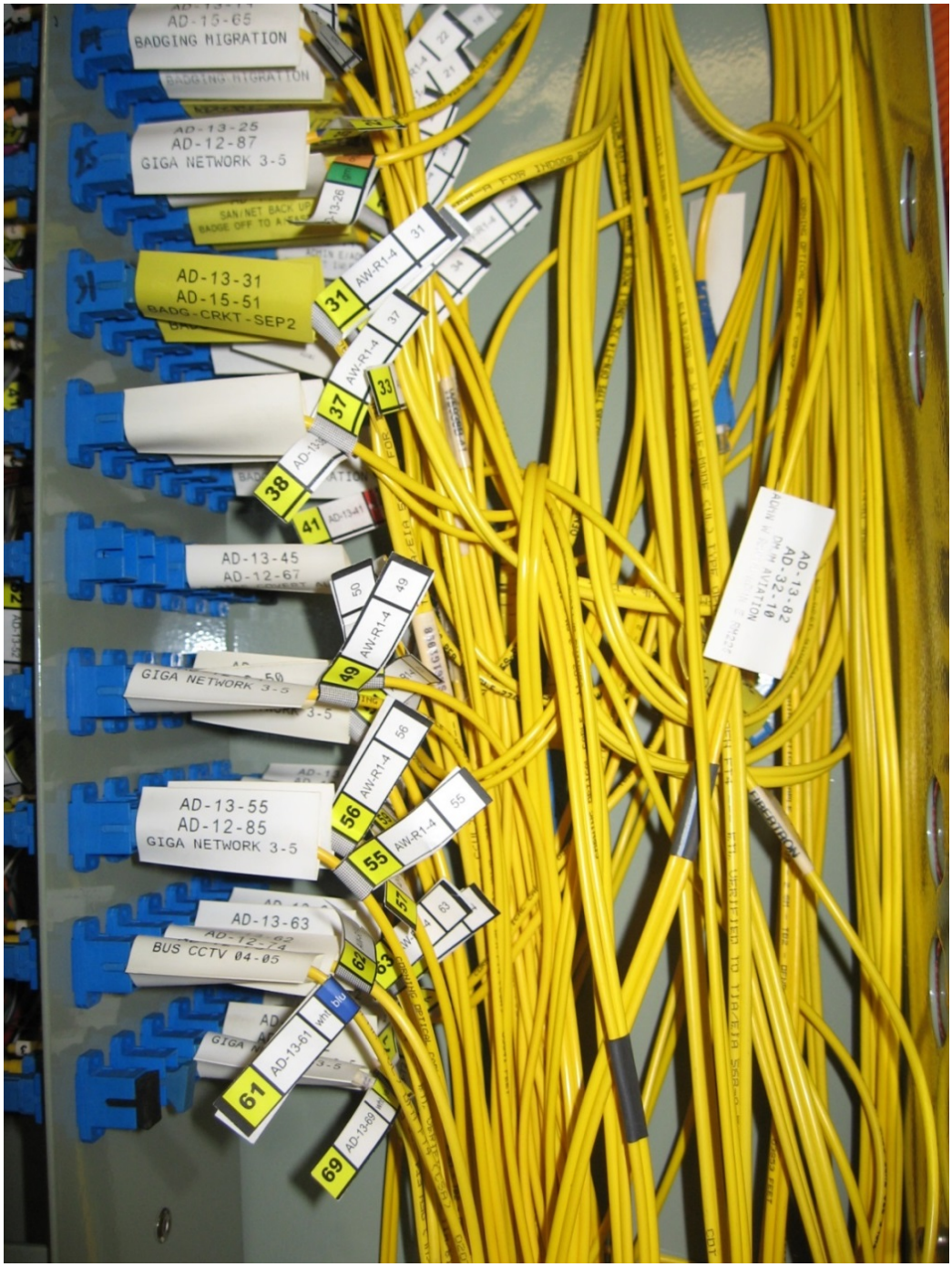
A sample of legacy (previously LAWA-required fiber connectors is shown.

3.8. COMMON ELEMENTS > FIBER CUTOVERS

3.8.1. Contractor shall prepare a fiber cutover plan for LAWA's review and approval.

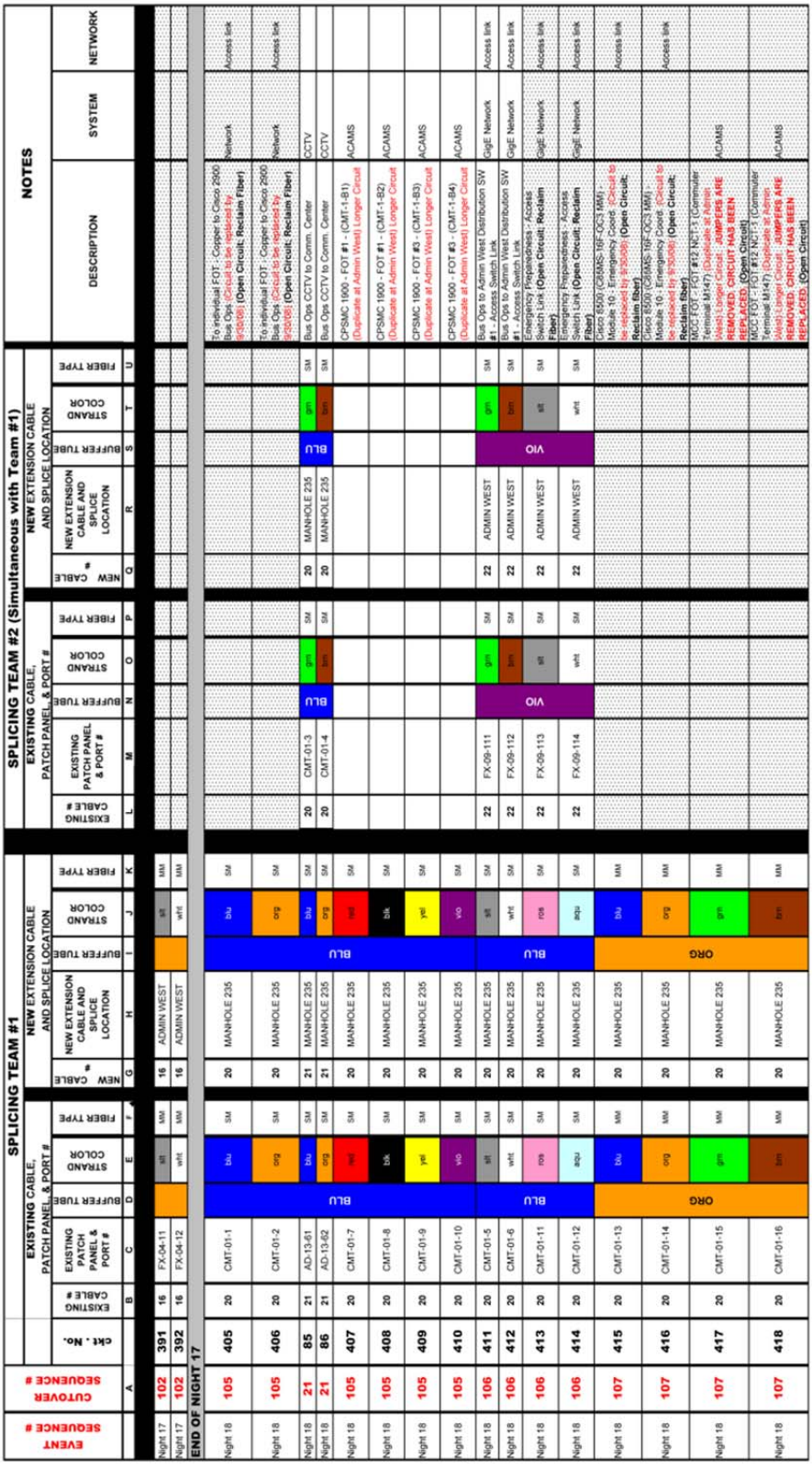
3.8.2. Contractor shall survey all required fiber cables, maintenance holes, and jumpers for any fiber optic cutovers.

3.8.3. Contractor shall individually label all fiber optic jumpers that are required to relocate to a different patch panel.



A patch panel with additional survey tags in preparation for cutover is shown.

3.8.4. Contractors shall prepare an Excel spreadsheet detailing each fiber jumper's original and final destination for LAWA's review and pre-approval.



EVENT SEQUENCE #	CUTOVER SEQUENCE #	SPLICING TEAM #1										SPLICING TEAM #2 (Simultaneous with Team #1)										NOTES	
				EXISTING CABLE, PATCH PANEL, & PORT #				NEW EXTENSION CABLE AND SPLICE LOCATION				EXISTING CABLE, PATCH PANEL, & PORT #				NEW EXTENSION CABLE AND SPLICE LOCATION				DESCRIPTION	SYSTEM
		Ckt. No.	EXISTING CABLE #	EXISTING PATCH PANEL & PORT #	BUFFER TUBE	STRAND COLOR	FIBER TYPE	NEW CABLE #	NEW EXTENSION CABLE AND SPLICE LOCATION	BUFFER TUBE	STRAND COLOR	EXISTING CABLE #	EXISTING PATCH PANEL & PORT #	BUFFER TUBE	STRAND COLOR	FIBER TYPE	NEW CABLE #	NEW EXTENSION CABLE AND SPLICE LOCATION	BUFFER TUBE	STRAND COLOR	FIBER TYPE		
	A		B	C	D	E	F	G	H	I	J	L	M	N	O	P	Q	R	S	T	U		
Night 17	102	391	16	FX-04-11		slt	MM	16	ADMIN WEST		slt												
Night 17	102	392	16	FX-04-12		wht	MM	16	ADMIN WEST		wht												
END OF NIGHT 17																							
Night 18	105	405	20	CMT-01-1	BLU	blu	SM	20	MANHOLE 235	BLU	blu											To individual FOT - Copper to Cisco 2900 Bus Ops (Circuit to be replaced by 4/5/06) (Open Circuit; Reclaim Fiber)	Network
Night 18	105	406	20	CMT-01-2	BLU	org	SM	20	MANHOLE 235	BLU	org											To individual FOT - Copper to Cisco 2900 Bus Ops (Circuit to be replaced by 4/5/06) (Open Circuit; Reclaim Fiber)	Network
Night 18	21	85	21	AD-13-61	BLU	blu	SM	21	MANHOLE 235	BLU	blu	20	CMT-01-3	BLU	grn	SM	20	MANHOLE 235	BLU	grn	SM	Bus Ops CCTV to Comm. Center	CCTV
Night 18	21	86	21	AD-13-62	BLU	org	SM	21	MANHOLE 235	BLU	org	20	CMT-01-4	BLU	brn	SM	20	MANHOLE 235	BLU	brn	SM	Bus Ops CCTV to Comm. Center	CCTV
Night 18	105	407	20	CMT-01-7	BLU	red	SM	20	MANHOLE 235	BLU	red											CPSMC 1900 - FOT #1 - (CMT-1-81) (Duplicate at Admin West) Longer Circuit	ACAMS
Night 18	105	408	20	CMT-01-8	BLU	blk	SM	20	MANHOLE 235	BLU	blk											CPSMC 1900 - FOT #1 - (CMT-1-82) (Duplicate at Admin West) Longer Circuit	ACAMS
Night 18	105	409	20	CMT-01-9	BLU	yel	SM	20	MANHOLE 235	BLU	yel											CPSMC 1900 - FOT #3 - (CMT-1-83) (Duplicate at Admin West) Longer Circuit	ACAMS
Night 18	105	410	20	CMT-01-10	BLU	vio	SM	20	MANHOLE 235	BLU	vio											CPSMC 1900 - FOT #3 - (CMT-1-84) (Duplicate at Admin West) Longer Circuit	ACAMS
Night 18	106	411	20	CMT-01-5	BLU	slt	SM	20	MANHOLE 235	BLU	slt	22	FX-09-111	VIO	grn	SM	22	ADMIN WEST	VIO	grn	SM	Bus Ops to Admin West Distribution SW #1 - Access Switch Link	GigE Network
Night 18	106	412	20	CMT-01-6	BLU	wht	SM	20	MANHOLE 235	BLU	wht	22	FX-09-112	VIO	brn	SM	22	ADMIN WEST	VIO	brn	SM	Bus Ops to Admin West Distribution SW #1 - Access Switch Link	GigE Network
Night 18	106	413	20	CMT-01-11	BLU	ros	SM	20	MANHOLE 235	BLU	ros	22	FX-09-113	VIO	slt	SM	22	ADMIN WEST	VIO	slt	SM	Emergency Preparedness - Access Switch Link (Open Circuit; Reclaim Fiber)	GigE Network
Night 18	106	414	20	CMT-01-12	BLU	aqu	SM	20	MANHOLE 235	BLU	aqu	22	FX-09-114	VIO	wht	SM	22	ADMIN WEST	VIO	wht	SM	Emergency Preparedness - Access Switch Link (Open Circuit; Reclaim Fiber)	GigE Network
Night 18	107	415	20	CMT-01-13	ORG	blu	MM	20	MANHOLE 235	ORG	blu											Cisco 6500 (C6MS-16F-DCI MM) - Module 10 - Emergency Coord. (Circuit to be replaced by 3/30/06) (Open Circuit; Reclaim fiber)	Access link
Night 18	107	416	20	CMT-01-14	ORG	org	MM	20	MANHOLE 235	ORG	org											Cisco 6500 (C6MS-16F-DCI MM) - Module 10 - Emergency Coord. (Circuit to be replaced by 3/30/06) (Open Circuit; Reclaim fiber)	Access link
Night 18	107	417	20	CMT-01-15	ORG	grn	MM	20	MANHOLE 235	ORG	grn											MCC FOT - FOT #12 NCIT-1 (Commuter Terminal M147) (Duplicate at Admin West) Longer Circuit - JUMPERS ARE REMOVED, CIRCUIT HAS BEEN REPLACED. (Open Circuit)	ACAMS
Night 18	107	418	20	CMT-01-16	ORG	brn	MM	20	MANHOLE 235	ORG	brn											MCC FOT - FOT #12 NCIT-1 (Commuter Terminal M147) (Duplicate at Admin West) Longer Circuit - JUMPERS ARE REMOVED, CIRCUIT HAS BEEN REPLACED. (Open Circuit)	ACAMS

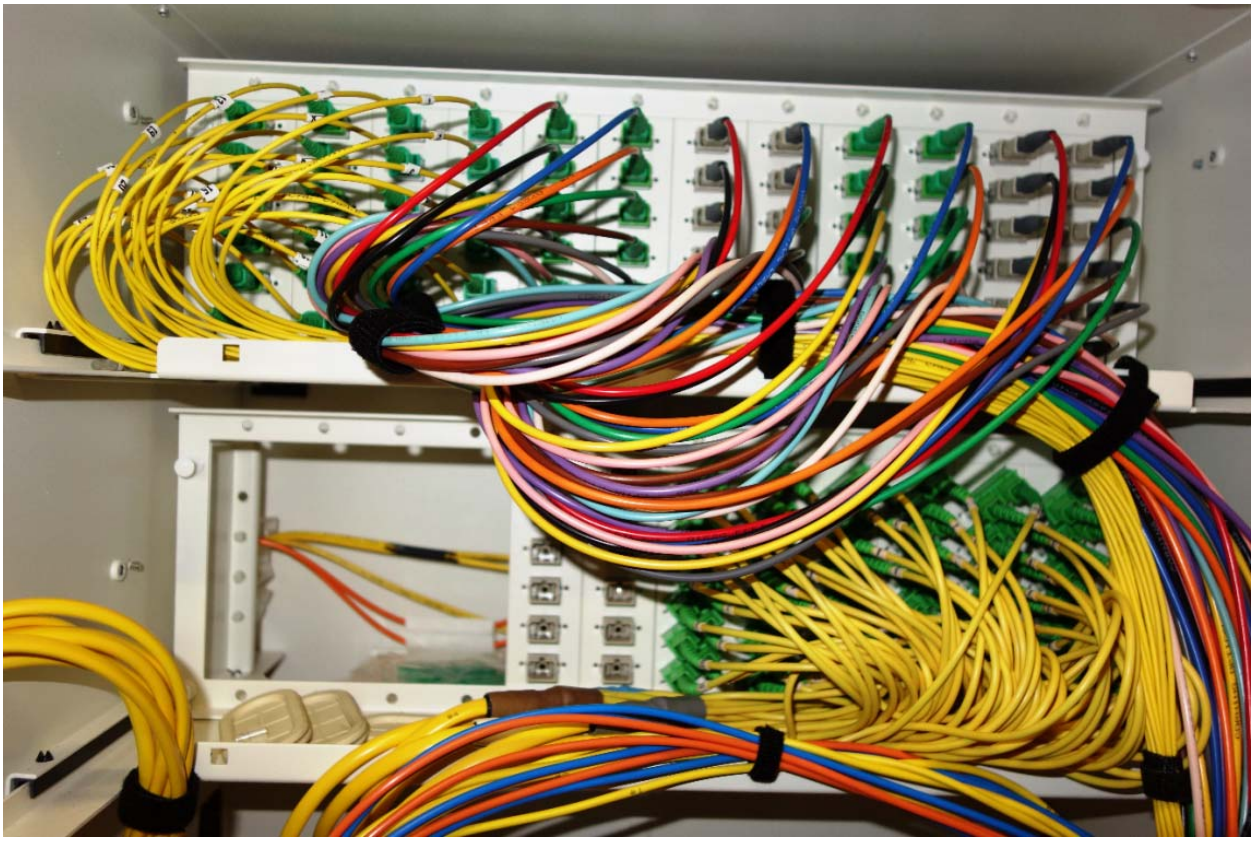
A sample of a spreadsheet in preparation for a fiber cutover is shown.

3.9. COMMON ELEMENTS > FIBER PANELS > RACK-MOUNT

3.9.1. Rack-mount Fiber Patch Panels (FPP) shall be sized for a minimum of 144 double density or 288 strands of fiber.

3.9.2. Fiber cable strands may be connectorized by one of three (3) methods: a) Factory-polished and connectorized 6-foot LC pigtails, b) Factory-polished and connectorized LC single 6-foot fiber jumpers, c) Factory-polished cassettes.

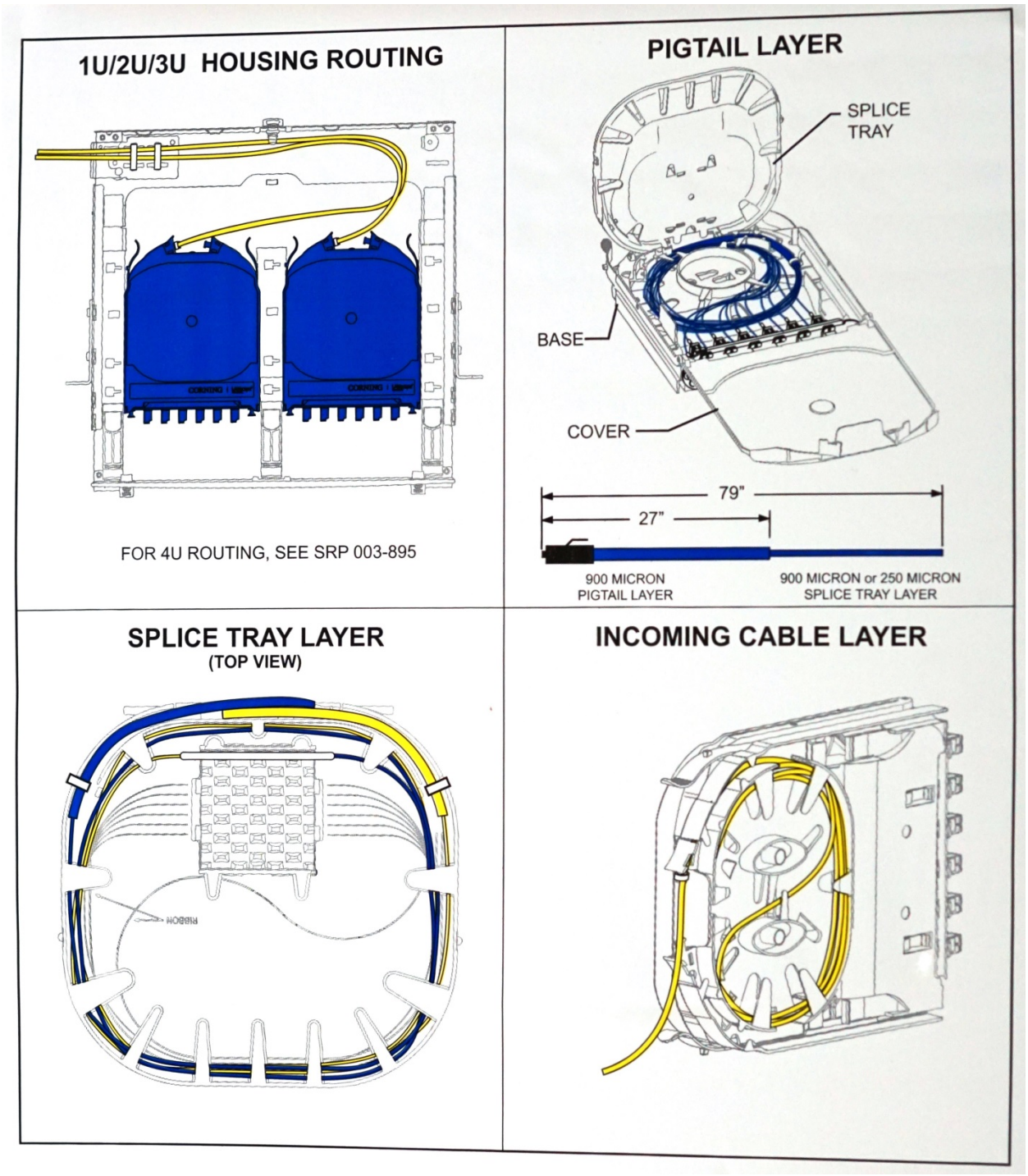
3.9.3. If fiber pigtails are all the same color, then each pigtail shall be labeled with the fiber strand number. Pigtails that are color-coded do not required numbered labels.



Pigtails of the same color shall be labeled with the strand number.

3.9.4. Pigtails, jumpers, and cassette connectors shall be fusion-spliced to the cable strands.

Pigtails of the same color shall be labeled with the strand number.



Fiber cassette shown. Courtesy: Corning.

Picture of an actual fiber optic cassette.

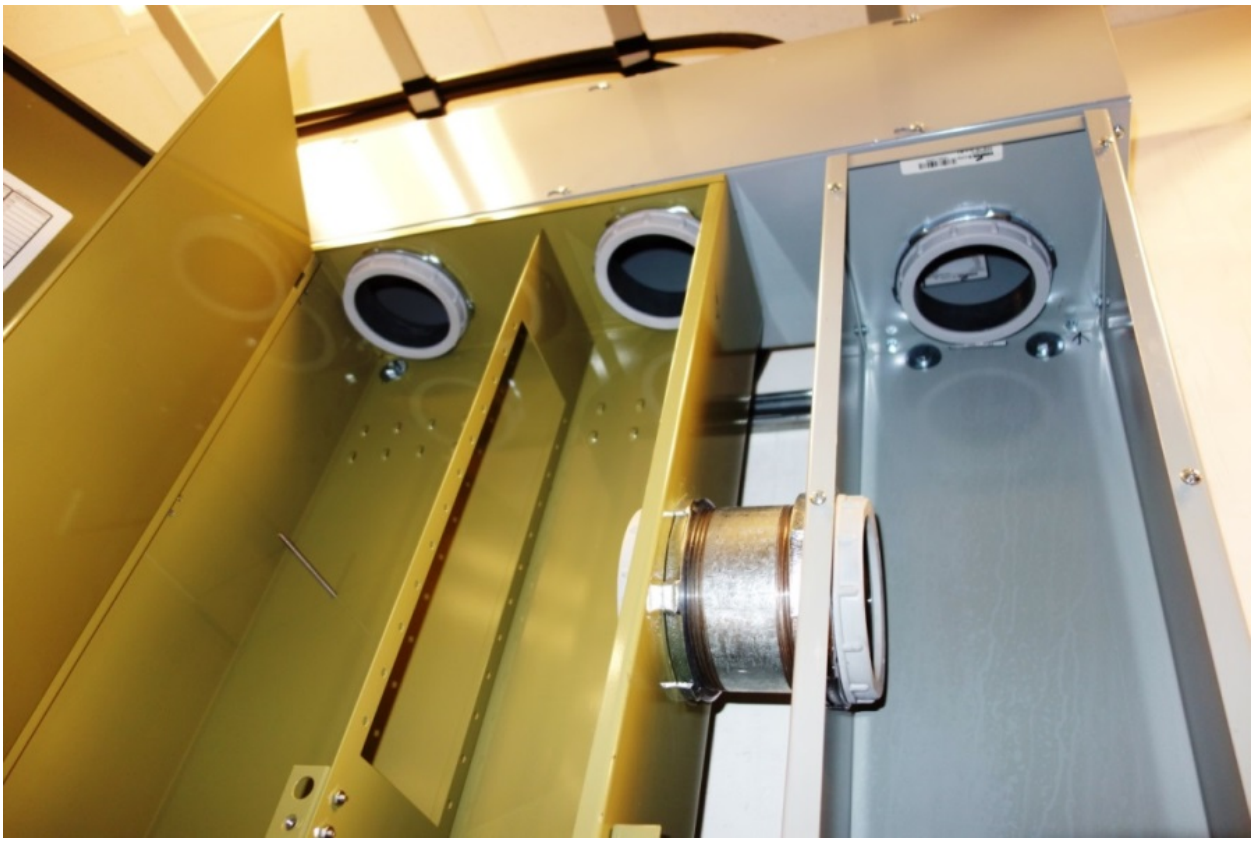
Fiber patch panels shall be mounted together within cabinets.

3.10. COMMON ELEMENTS > FIBER PANELS > WALL-MOUNT

3.10.1. Wall-mount FPP's shall be sized for a minimum of 144 double density or 288 strands of fiber.

3.10.2. Wall-mount FPP's shall stand off the wall by a minimum of 3-inches to coil up slack cable behind. FPP's shall also have an 8-inch wireway gutter all around the FPP for fiber jumpers – see existing installations.

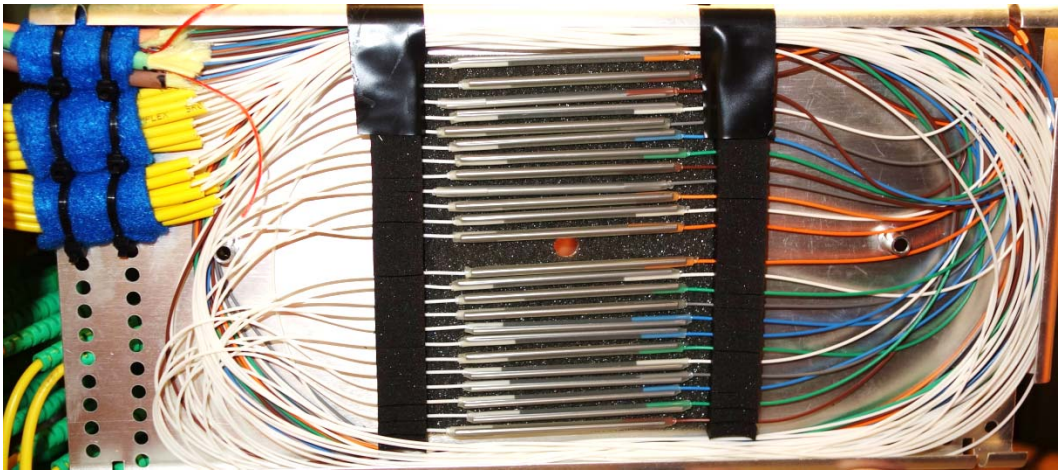
Wall-mount FPP's shall have wireway and six 4-inch chase nipples installed as shown.



Conduit chase nipples shown connecting patch panel to top and right wireway.

3.11. COMMON ELEMENTS > FIBER SPLICING

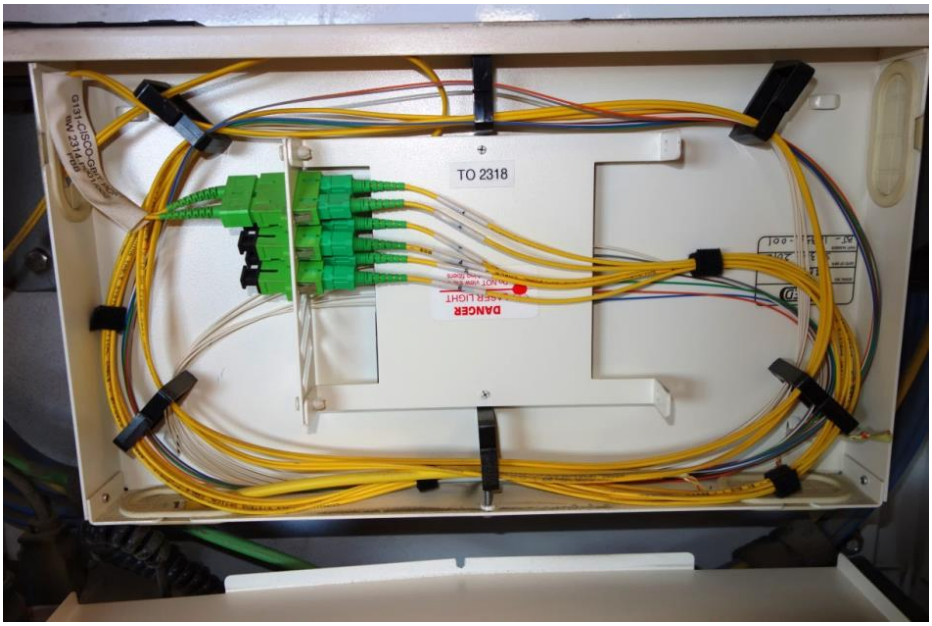
3.11.1. All splices shall be fusion-spliced. Mechanical splices are not allowed.



Typical fiber splice tray with fusion splices.

3.11.2. Corning and Fujikura splicers are approved for fusion splicing.

3.11.3. All fusion splices shall be padded and protected.

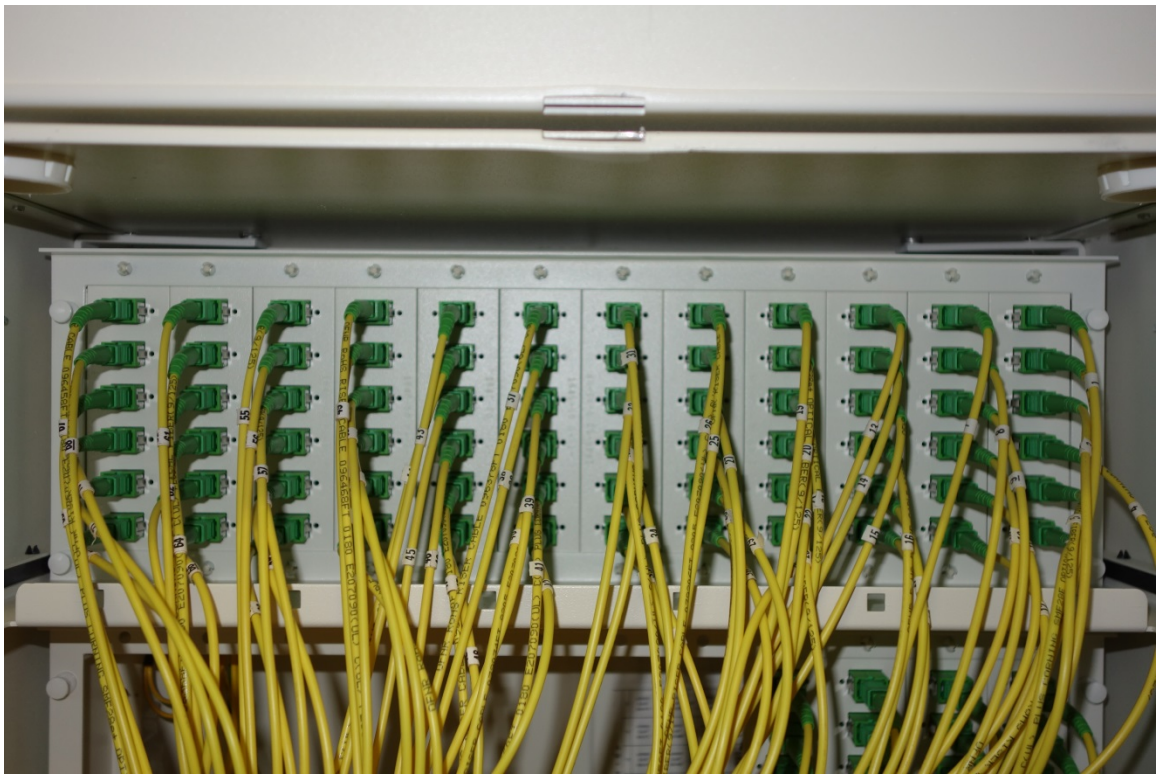


Fusion splices shown here are protected behind metal panel.

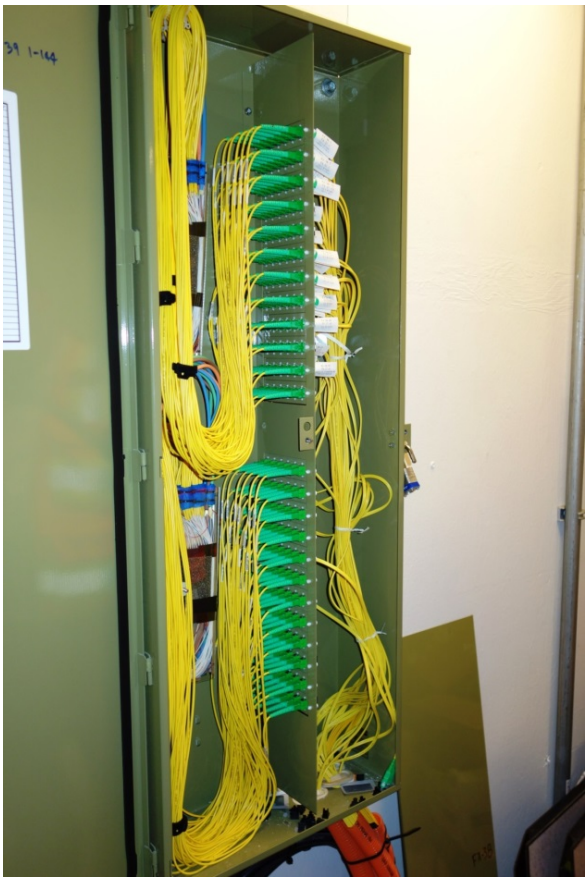
3.11.4. All fusion slices shall be reinforced with heat shrink sleeves reinforced with metal rods.

3.11.5. All buffer tubes, pigtails, and jumpers used as pigtails shall be protected with padding and secured in place to prevent movement without constricting fibers.

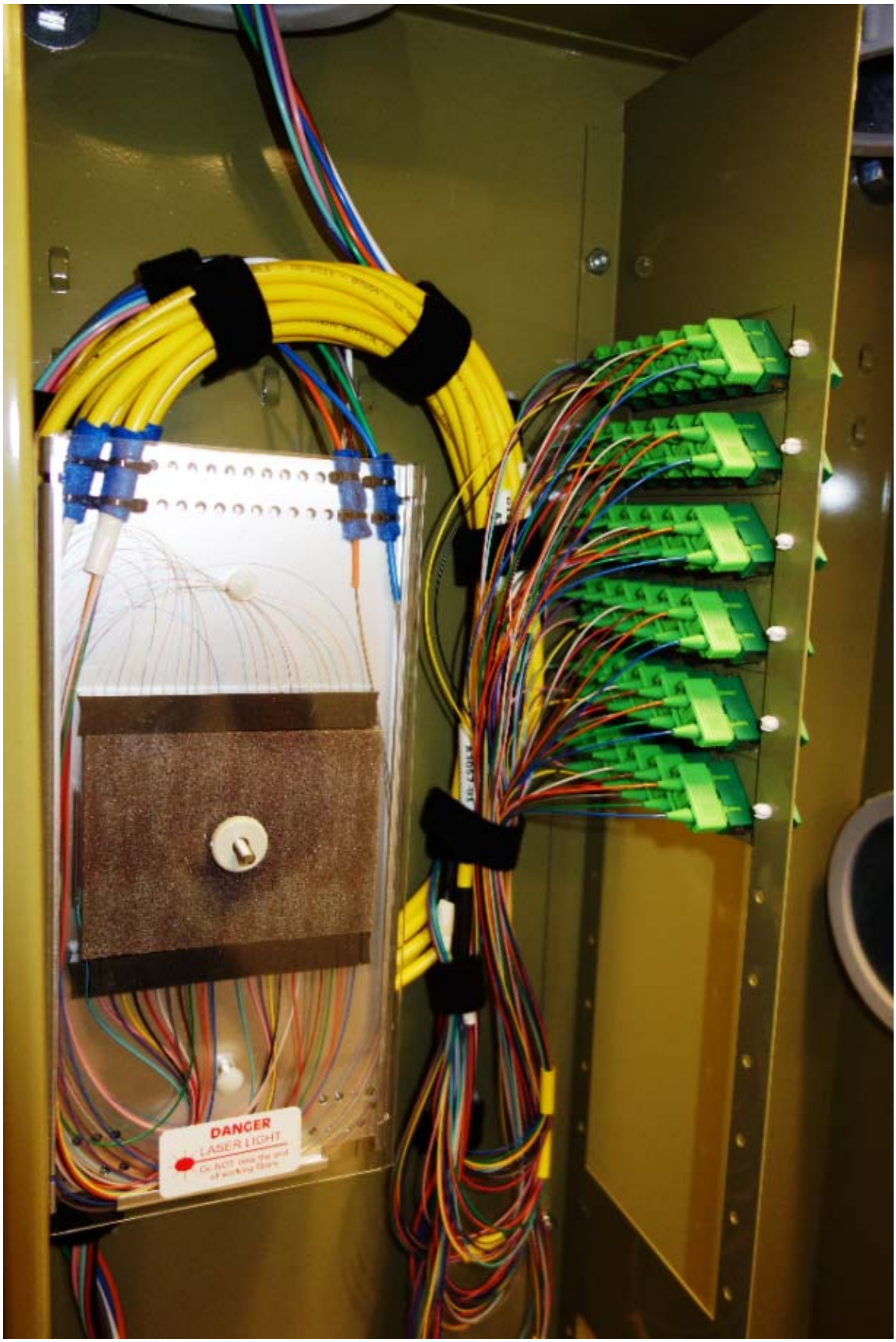
3.11.6. Outdoor splices shall be protected by Corning or Coyote type waterproof enclosures.



Rear view of a rack-mount fiber panel showing each pigtail labeled with fiber strand number.



Side view of a wall-mount fiber panel showing each pigtail labeled with fiber strand number.



Color-coded pigtails spliced to fiber cable in splice case is shown.

3.12. COMMON ELEMENTS > FIBER TEST EQUIPMENT

3.12.1. Below are suggested manufacturers of LAWA's standard equipment used for cleaning, testing, certifying and troubleshooting fiber optic cables and circuits.

3.12.2. All testing equipment shall be calibrated within a year of conducting tests and shall contain the most recent ANSI/TIA testing protocols for certifying the test results.

3.12.3. LAWA reserves the right to see test equipment calibration records anytime requested.

A 400x fiber microscope is required to examine singlemode fiber.

Fiber optic cleaning supplies are required to be used with test equipment.

A live fiber circuit finder is required when verifying the correct circuit to work on.

An Optical Time Domain Reflectometer is required to test, certify, and troubleshoot fibers.

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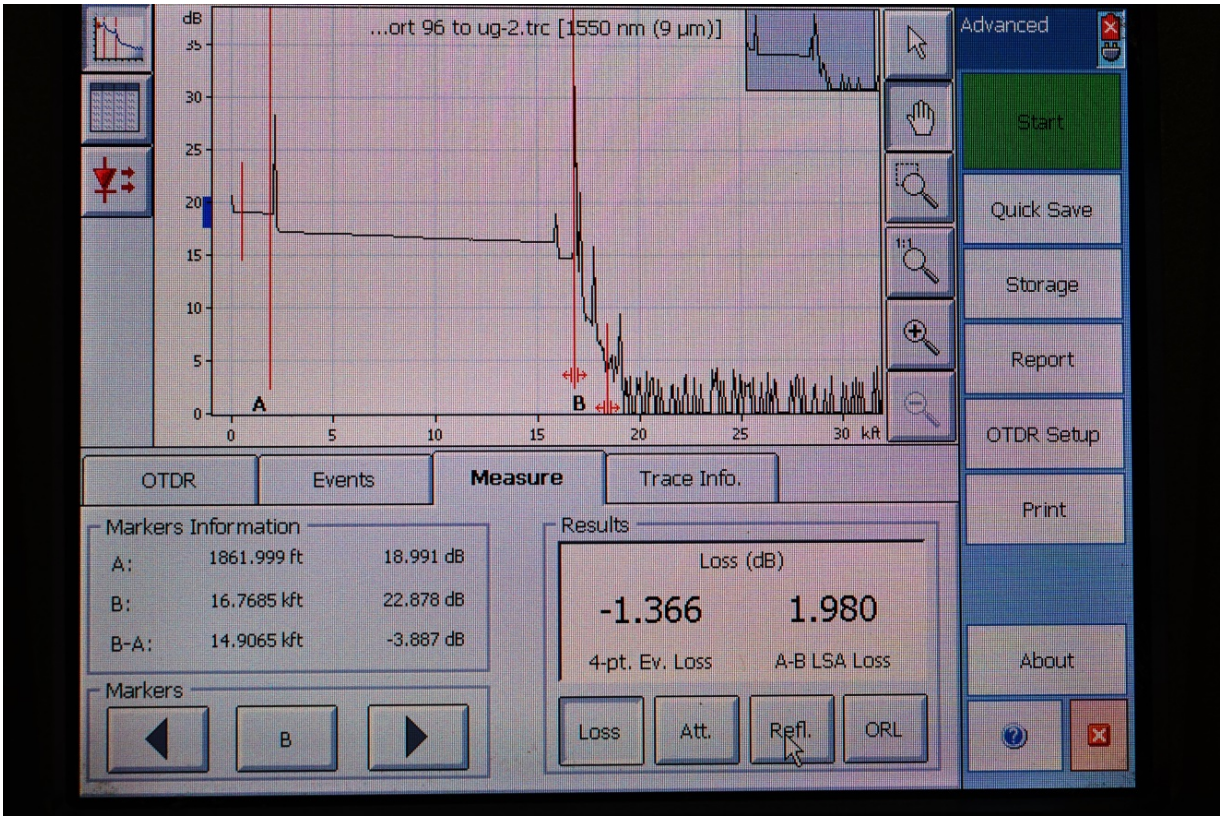
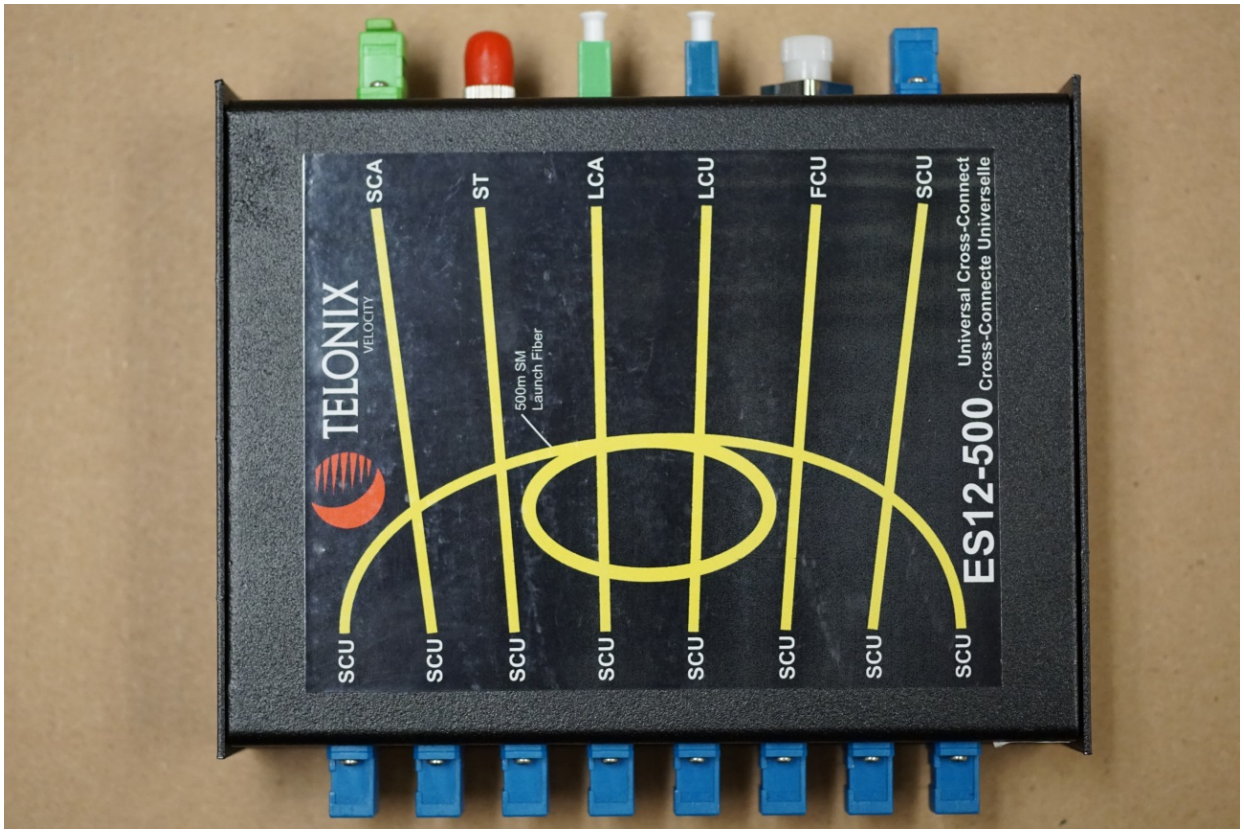


Picture of a typical OTDR tracing.

A professional fiber optic launch box is required when using OTDR's.



A fiber optic connector converter box is helpful in connector-diverse environments.

A fiber optic fusion splicer is required joining fiber strands, and older model is shown.

A fiber optic fusion splicer is required joining fiber strands, and newer model is shown.

A Fiber optic light source and power meter is required for obtaining accurate signal loss levels.

A Fiber optic light source and power meter is required for obtaining accurate signal loss levels.

3.13. COMMON ELEMENTS > FIBER TESTING

3.13.1. All fiber cable backbone segments and end-to-end fiber circuits shall be tested according to the following chart.

Function	Manufacturer Test Results	Onsite Reels	Indoor Backbone Segments After Pigtails Installed	Outdoor Backbone Segments After Pigtails Installed	End-to-End Circuit
Clean		Required	Required	Required	Required
400X Inspection Scope			Required	Required	Required
Unidirectional OTDR		Required	Required		Required
Bidirectional OTDR				Required	Required
Bidirectional Optical Loss Test Set (OLTS) (Power Meter)			Required	Required	Required
Bidirectional Optical Return Loss (ORL)					Required
Note 1: All singlemode tests shall be conducted at both 1310 and 1550 nm wavelengths.					
Note 2: All multimode tests shall be conducted at both 850 and 1300 nm wavelengths.					
Note 3: Inspection scope, OTDR, OLTS, and ORL results shall be submitted in PDF form.					
Note 4: OTDR tests shall include graphic tracings and events - not just Pass/Fail results.					
Note 5: All Manufacturer test results shall be submitted to LAWA upon receipt.					
Note 6: All test results shall be submitted to LAWA within one week of testing.					

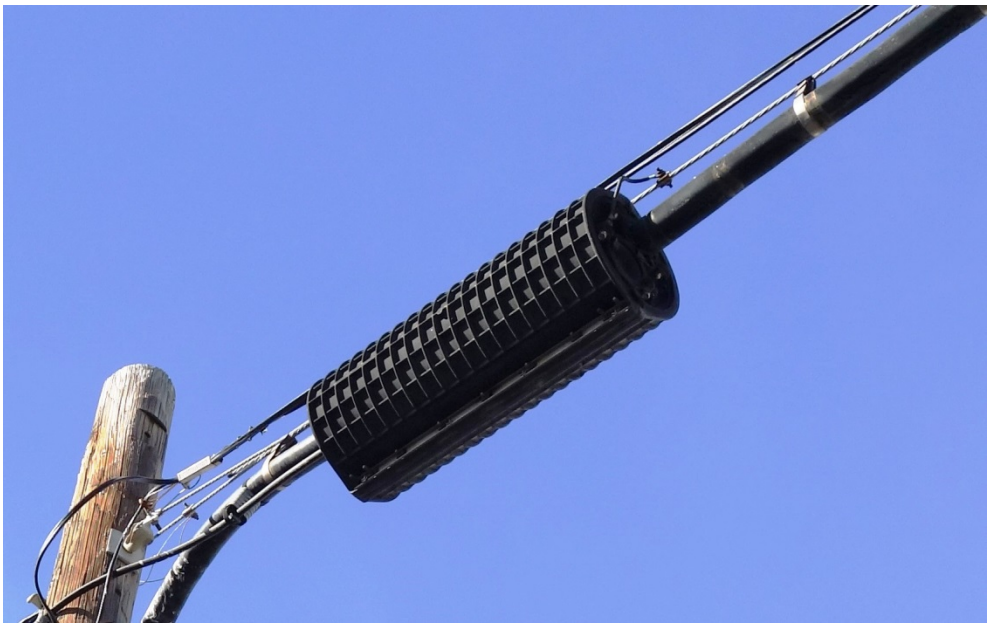
A matrix chart showing the required fiber optic tests.

3.14. COMMON ELEMENTS > SPLICE CASES

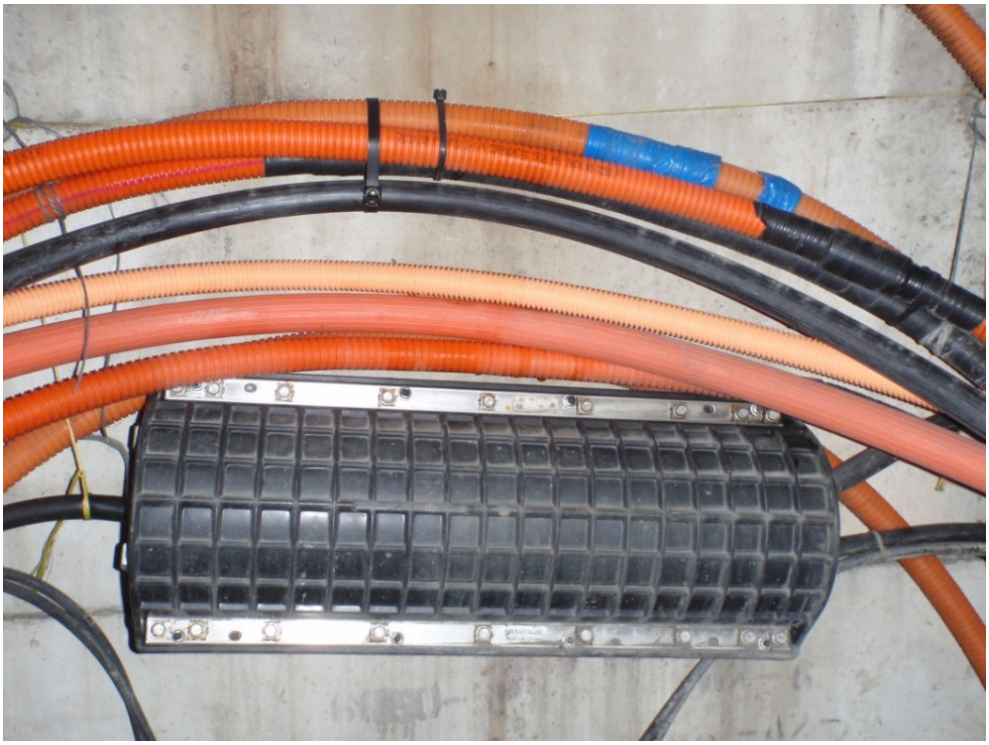
3.14.1. Indoor and outdoor Coyote-type splice cases are allowed.

3.14.2. Splice points shall be used when there is a need not a convenience.

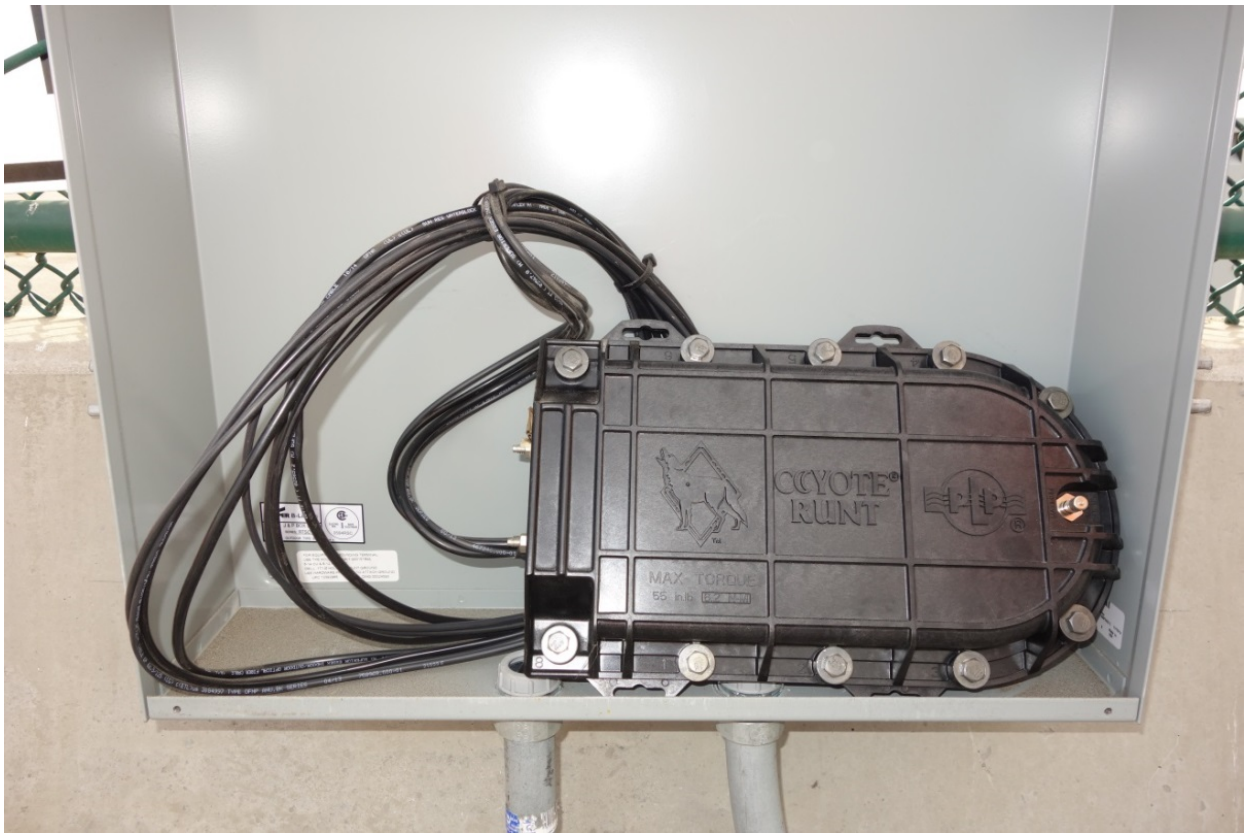
3.14.3. Splice case locations shall be documented on as-built drawings.



An outdoor aerial splice case shown supported by a stringer wire.

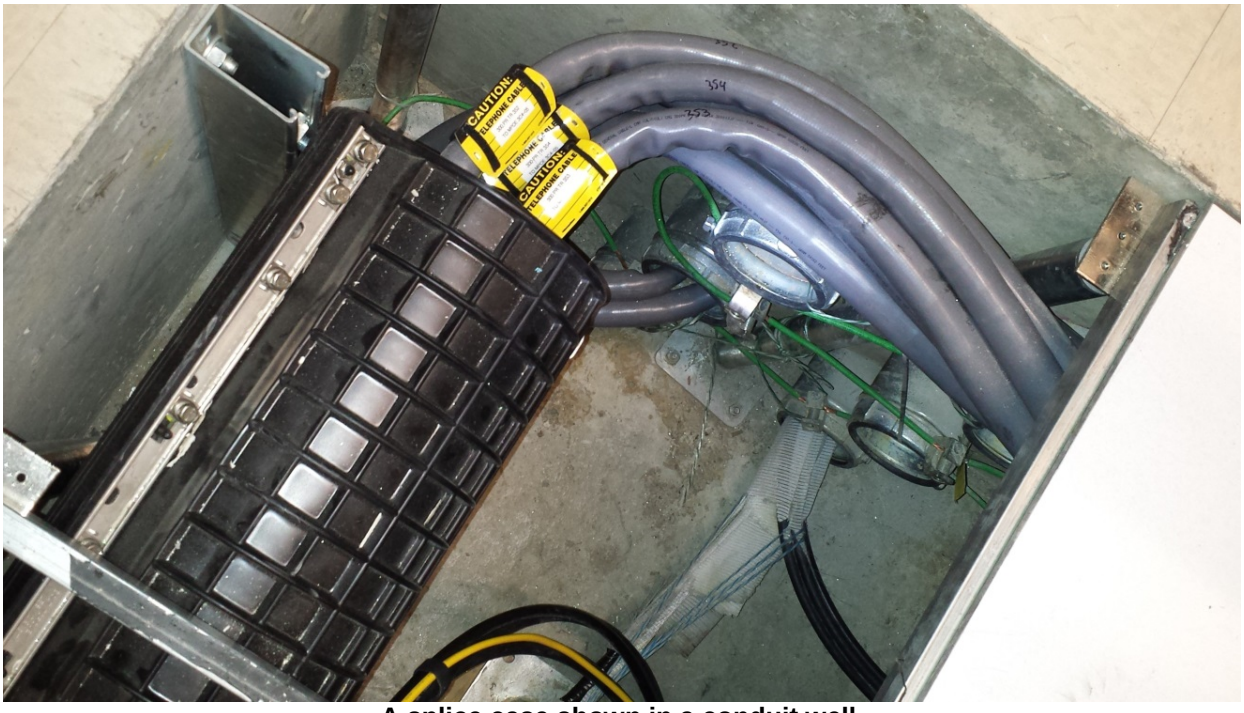


An outdoor underground splice case shown.



An intermediate outdoor splice case on a long fiber run shown in a junction box.

Splice case shown on a ladder rack.



A splice case shown in a conduit well.