



Construction Services for Fiber Optic Broadband  
Infrastructure  
Request for Proposals  
ISL-2017-01

Town of Islesboro  
150 Main Road  
Islesboro, ME 04848  
[www.townofislesboro.com](http://www.townofislesboro.com)

June 16, 2017

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# 1. Request for Proposals Overview

## 1.1. General Information

Through this Request for Proposals (RFP), the Town of Islesboro is seeking an experienced fiber optic network equipment installation and testing firm to perform services related to fiber optic facilities in Islesboro, Maine. The fiber network is open access and designed to support use by the community. Respondents will be asked to provide pricing for Scope B services outlined below for managing the construction and network installation tasks detailed below.

## 1.2. Expected RFP Schedule

Unless otherwise indicated, all deadlines are 1:00 PM EDT on the date listed.

RFP POSTED	June 16, 2017
NOTIFICATION OF INTENT TO RESPOND DUE	June 22, 2017
MANDATORY PRE-BID CONFERENCE CALL	June 29, 2017 11:00 a.m.
RFP Q&A CONFERENCE CALL	July 6, 2017
WRITTEN QUESTIONS DUE	July 13, 2017
Q&A POSTED	July 14, 2017
PROPOSALS DUE	July 26, 2017

# 2. Background

The Town of Islesboro intends to build and own a fiber optic and wireless network connecting community anchor institutions (CAIs), private enterprises, and the residences of the Town of Islesboro. The Town of Islesboro is a municipal corporation organized and existing under the laws of the State of Maine.

The Town of Islesboro is seeking an entity or entities capable of performing equipment installation and testing services for Scope B of our project as described in the RFP. This RFP along with the appendices and attachments are critical in understanding the level of work required by the Contractor.

Respondents shall describe in their proposal their approach and firm, fixed-price bid for installing and testing the work as described in this RFP.

For bids which include teams of more than one firm, the Town of Islesboro expects each bid team to identify one firm as the General Contractor (General Contractor or GC). Collectively each entity, and other teamed entities are referred to as "Bidders," "Contractors," "Proposers" or "Respondents" in this RFP. The General Contractor shall be responsible for purchase, installation and testing of equipment, insurance, and bonding. The Owner's Project Manager (OPM), James W. Sewall Company, will oversee construction to ensure compatibility with the proposed network infrastructure.

## 2.1. Islesboro Background

Islesboro is a vibrant island community in Waldo County, Maine, located approximately three miles off the coast of Lincolnville in Penobscot Bay. The Lincolnville-to-Islesboro ferry provides access to the island with seven week-day round trips per day, and expands to nine week-day round trips per day from the end of March to mid-October. There is also a Quicksilver water taxi that makes two weekday morning trips from Lincolnville to Islesboro at 6:10 AM and 6:45 AM.

The Town now has over 600 year-round residents. Islesboro's population swells to over 2,000 people in the summer months, when many seasonal residents return to vacation with family and friends. That being said, traffic on the island will be at its peak while construction of the network is taking place.

## 2.2. Project Background

**Contracts arising from this RFP will be conditionally awarded and executed, with payment and performance obligations subject to Board of Selectmen approval of the contract price.**

The following companies are associated with this project, and are cited throughout this RFP:

- The Town of Islesboro is the Owner and duly authorized to enter into contract negotiations.
- Tilson Technology Management (Tilson) is the original designer of the Town of Islesboro's fiber-to-the-premises (FTTP) system.
- Waveguide of Nashua NH is the Town of Islesboro's outside plant contractor and designer of the "as built" network.
- Biddeford Internet Corporation d/b/a Great Works Internet (GWI) is the proposed network operator for the Town of Islesboro. GWI will maintain and deliver service over the network under a public-private partnership.
- James W. Sewall Company, of Old Town, Maine, is the Owner's Project Manager.
- Central Maine Power Company (CMP), a subsidiary of Iberdrola USA Networks, is the local electric utility.
- Northern New England Telephone Operations, LLC d/b/a FairPoint Communications – NNE (FairPoint) is the local communications utility.

## 3. General Information

### 3.1. Response Information

#### 3.1.1. Single Point of Contact

All communications concerning this Request for Proposal (RFP) are to be sent by email to:

Vernon Ziegler, Assessor  
Town of Islesboro  
150 Main Road  
Islesboro, Maine 04848  
Phone: (207) 734-2253  
Fax: (207) 734-8394  
e-mail: [assessor@townofislesboro.com](mailto:assessor@townofislesboro.com)

### 3.1.2. Mandatory Pre-Bid Conference Call

Each Proposer must attend the mandatory pre-bid conference call and inform itself of the conditions relating to the area in which the construction services shall be performed. The pre-bid conference call on June 29, 2017 will begin at 11:00 A.M. via conference bridge provided to all Proposers by Owners, 150 Main Road, Islesboro, Maine. The Town disclaims any and all responsibility for injury to Proposers, their agents or others while examining the site or at any other time.

### 3.1.3. Questions and Answers

Questions about the Request for Proposal and the proposal contents need to be in writing and submitted to Vernon Ziegler on or before the date listed in Section 1.2. Questions will be answered during a conference call on the date listed in Section 1.2. All questions and answers will be posted in the Question and Answers file under RFP ISL-2017-01 on the Islesboro List of Published Requests on [www.townofislesboro.com/bbrfp2](http://www.townofislesboro.com/bbrfp2) by the date listed in Section 1.2.

### 3.1.4. Revisions to RFP

If the Owner determines that it is necessary to revise any part of this RFP, or if additional data is necessary to clarify any of its provisions, a supplement will be posted to the Owner's website. The Owner reserves the right to amend the RFP at any time prior to the deadline for submission of responses, and will notify all bidders who are on the Owner's distribution list via the mandatory pre-bid meeting attendance sheet.

### 3.1.5. Bid Deposit

All Bidders must submit a bid deposit in an amount equal to 10% of the bid amount in the form of a bid bond or certified check made payable to the Town of Islesboro. Bid deposits shall be returned upon the signing of a contract in substantially the same form as shown on Appendix A: Owner-Contractor Agreement, which shall be signed, if at all, no later than eighty (80) days after the opening of bids, and also shall be returned in the event that the Owner rejects all bids. Should a Bidder withdraw its proposal prior to the signing of a contract between the successful bidder and the Owner, the Bidder's bid deposit shall be forfeited to the Town of Islesboro.

No Proposals may be withdrawn within a period of eighty (80) days after the opening of Proposals. Proposals may be held by the Town for a period not to exceed eighty (80) days from the date of the opening of Proposals for the purpose of reviewing proposals and investigating the qualifications of the Proposers prior to the award of a contract.

### 3.1.6. Proposal Deadline

Please provide the Town with an original plus seven (7) copies of the firm's proposal in a sealed envelope, marked "Broadband Infrastructure Proposal – Scope B," addressed to Islesboro's Single Point of Contact at 150 Main Road, Islesboro, ME 04848. Proposals must be submitted in hardcopy form, and may be supplemented with an electronic copy within the sealed bid envelope. Proposals must be received by the Town on or before **1:00 P.M. EDT on the date listed in Section 1.2**. Proposals received after that date and time will not be considered.

### 3.1.7. Bid Opening

Bids shall be opened by the Town Manager, or the Manager's designee, in public on July 27, 2017 at 10:00 A.M. at:

Islesboro Town Office  
150 Main Road  
Islesboro, ME 04848

A tabulation of all received bids will be made available for public inspection.

## 3.2. Other Preparation Information

### 3.2.1. Proposal Acceptance

The Owner reserves the right to accept or reject any or all proposals, in whole or in part, as deemed to be in the best interest of the Town of Islesboro. The Owner may elect to negotiate with multiple entities prior to making final decisions.

### 3.2.2. Business Good Standing

To be awarded a contract by the Town of Islesboro, a Respondent must demonstrate that it is authorized to conduct business in Maine as evidenced by a certificate of good standing from the Maine Secretary of State's Office.

### 3.2.3. Costs of Preparation

The Respondent shall be solely responsible for all expenses incurred in the preparation of a response to this RFP and shall be responsible for all expenses associated with any presentations or demonstrations associated with this request and/or any proposals made.

### 3.2.4. Other Response Information

Unless otherwise specified in this RFP, all communications, responses, and documentation must be in English, and all cost proposals or figures in U.S. currency. All responses must be submitted in accordance with the specific terms of this RFP.

The Owner may provide reasonable accommodations, including providing material in an alternative format, for qualified Respondents with disabilities or other hardships. Respondents requiring such accommodations shall submit requests in writing, with supporting documentation justifying the accommodations, to the Owner.

## 3.3. Contract Award Information

The Owner may award one or more contracts, and reserves the right to make additional awards to the same bidder at any time during the contract term if such award is deemed to be in the best interest of the Town of Islesboro.

### 3.4. Contract Evaluation

The Owner intends to evaluate all submitted proposals as quickly as possible. Upon completion of the evaluation process, the Owner may select one or more Contractors with which to simultaneously execute contracts, based on the evaluation findings and other criteria deemed relevant for ensuring that the decision made is in the best interest of the Town of Islesboro.

### 3.5. Standard Terms and Conditions

The successful Proposer(s) shall be required to sign an Owner-Contractor Agreement substantially in the form attached hereto as Appendix A. Respondents should also familiarize themselves with the Town's Purchasing Policy, a copy of which is available at the Town Office, and on the Town's website at <http://www.townofislesboro.com/bbrfp2>.

### 3.6. Public Records

The successful response will become part of the contract file and will become a matter of public record as will all other responses received.

## 4. Scope B – Network Electronics & Equipment Installation

### 4.1. Performance Requirements

#### 4.1.1. General Information

This section provides key material and workmanship requirements for Point of Presence (POP) facilities and their care, electronics and equipment installations or removal and shall be a basis for audit and evaluation of a job. The workmanship items described in this section are both generic and specific in nature and may be applicable to all installation and removal operations. In addition, the experienced network equipment installation and testing firm shall adhere to the specific installation, removal, and operational standards established in applicable equipment specifications as well as all handbooks and technical information required to successfully complete installation or removal of the equipment.

The experienced network equipment installation and testing firm shall not deviate from standards or guidelines outlined in this section without written permission from the OPM. Any questions not answered by this section, the job specifications, drawings/records, etc. shall be referred to the OPM for resolution and documented in the job log by the Respondent.

#### 4.1.2. Network Equipment Specifications

See Appendices B through J.



#### 4.1.3. Installation Requirements

##### 4.1.3.1. Installation Scope

Installation work will be done in two locations:

1. within the POP Shelter that is currently under construction by Waveguide. The building is adjacent to the Town of Islesboro Town Office Building at 150 Main Rd.
2. A Fiber Distribution Hut on 700 Acre Island adjacent to the Dark Harbor Boat Yard. Bidder can contact the boat yard for information and costs regarding transportation to and from the island.

Bidder can assume that electrical, including backup power, and heating ventilation and air conditioning will be in place. Please refer to Appendix E: Point of Presence (POP) Installation Standards Guide.

##### 4.1.3.2. Network Equipment List

Please refer to Appendix D: Network Equipment Bill of Materials. It is required that firms provide a firm, fixed bid on the specific set of equipment from specific manufacturers contained in Appendix D at the minimum. The option to submit an alternate set of equipment that meets the network requirements at a lower cost, but similar warranty, to the Owner is in addition to the requirement stated above. Excess materials purchased but not used during the construction will be property of the Owner upon acceptance of the network.

Please be aware that all necessary construction equipment of the Contractor to be transported from Lincolnville, ME to Islesboro, ME on the MV Margaret Chase Smith ferry is subject to cargo dimension limits of: 60' x 10' x 15'.

##### 4.1.3.3. Staging Area

The staging area for all network equipment will be the POP Shelter. All building construction within the areas designated for POP equipment shall be completed before the scheduled start of the network equipment installation activity. Any exceptions shall be subject to agreement between the Installer, the Owner, and its OPM.

##### 4.1.3.4. Network Equipment Testing

###### 4.1.3.4.1. Acceptance Test Plan (ATP)

The Contractor shall provide a comprehensive ATP(s) as follows:

- a. The Contractor shall develop and submit to the OPM within 15 days prior to any tests, an ATP for review and approval, which details all testing for all new material, cables and equipment based on final design and the minimum technical requirements, the manufacturer's recommended test procedures, and industry standard practices.

- b. The ATP shall include procedures and data forms for the OPM's review prior to the day the tests are to begin. The Test Plan shall include the sequence in which the tests will be conducted. The Test Plan shall have the OPM's approval prior to the start of testing.
- c. All test results, including results of failed tests or re-tests, shall be submitted, and delivered to the OPM. The data forms shall contain all of the data taken, as well as quantitative results for all tests. The data forms shall be signed by an authorized representative of the Contractor. At least one copy of the data forms shall be sent to the OPM within 10 working days of the test's conclusion.
- d. The OPM reserves the right to have a representative witness all tests. The results of each test shall be compared with the requirements specified herein. Failure to conform to the requirements of any test shall be counted as a defect, and the equipment shall be subject to rejection by OPM. Rejected equipment may be offered again for a retest, provided that all non-compliances have been corrected and retested and evidence thereof submitted to OPM.
- e. The Contractor shall be responsible for providing the test fixtures and test instruments for all the system and fiber optic related tests.
- f. The ATP shall cover all testing to demonstrate that the fiber and network are meeting the design intent and requirements.

#### 4.1.3.4.2. Original Equipment Manufacturer (OEM) Tests

Original Equipment Manufacturer (OEM) tests are performed by the OEMs in a controlled environment at the manufacturer's facilities. These tests shall consist of functional performance tests to determine the maximum performance limits of an item. These tests could measure such things as electronics characteristics, min/max operating temperatures, ability to withstand shock, vibration, dust, humidity, fungus, solar radiation, etc. and may include destructive tests. These tests shall be done in accordance with Industry standards.

#### 4.1.3.4.3. Lab System Prototype Tests

Individual components of the system must be combined into a prototypical test network or system. This testing can be accomplished at the equipment vendor's site, or location where equipment has previously been installed. Lab System Tests are aimed to simulate the logical environment of the system. Physical components such as fiber span distances and OSP/Facilities components are not part of the Lab System Prototype Tests.

The primary objectives of the Lab System Prototype Tests are to:

- a. Verify interoperability and operation of the individual components as an integrated system.
- b. Verify system and service functionality requirements (Fault recovery, QoS/CoS mechanisms, service provisioning, service monitoring, etc.).
- c. Verify system and service performance specs and baseline performance (Latency, Jitter, Packet Loss, BER) for reference during field acceptance testing.

#### 4.1.3.4.4. Conditional Acceptance Tests

Please refer to Appendix F: Conditional Acceptance Testing, for the guidelines associated with each level of conditional acceptance tests.

#### 4.1.3.5. Documentation Requirements

The Contractor will provide an as-built package at the completion of this project. This package shall include at a minimum the following items:

- Updated drawings with any changes implemented.
- Test results for the approved ATP.
- Warranty Package to include dates (Product Warranty)
- Certificate of Acceptance (pre-and post-installation)
- Summary sheet of test results for quick reference

Test results shall be provided as indicated in the testing sections of this specification. Drawings provided to the Respondent can be used as the basis for any as-built. If changes are noted in the field, they shall be indicated on the Respondent's updated drawings. The updated drawings shall be provided to the OPM via electronic data format and in hard copy (in color).

#### 4.1.3.6 Job Completion

Job completion occurs when all of the following conditions are met by the General Contractor:

1. submits last invoice;
2. notifies the Owner that construction is complete;
3. final inspection has occurred;
4. all punch list items have been completed;
5. all documentation has been completed and submitted to the town
  - a. Network Equipment Installation Project
  - b. Design As-Builts
  - c. Test data
  - d. Equipment Organization Drawing
  - e. Equipment testing

#### 4.1.4. Safety Requirements

The Contractor shall provide all safeguards, safety devices and protective equipment and take any other needed actions to reasonably protect the public and private property connection with the performance of the work covered by the contract.

The Contractor shall take the necessary precautions and bear the sole responsibility for the safety of the methods employed in performing the work. The Contractor shall at all times comply with the regulations set forth by Federal, State and local laws, rules, and regulations concerning "OSHA" and all applicable state labor laws, regulations and standards.

Please refer to Appendix E: Point of Presence (POP) Installation Standards Guide, for detailed guidelines pertaining to installation, cabling, fiber optic cable, wiring, connecting, power, batteries, bonding, and grounding.

4.1.5. Warranty Requirements

1. The Contractor shall warrant that all materials furnished shall be new, and free from defects.
2. The Contractor shall warrant that the materials and workmanship used in this installation are as herein specified, and shall provide all material and labor required to make good any defects due to faulty materials or workmanship which become apparent within a one year period from substantial completion.
3. The equipment and materials manufacturers are expected to recognize that they are responsible for the failure of their products to perform in accordance with data furnished by them or their authorized representatives, as well as misrepresentations of such data.
  - a. When the products have been installed in accordance to the manufacturer's published or written instructions and recommendations, and such products fail, then the Contractor and the manufacturers are responsible for replacement of the products and all associated work and materials without additional cost to the Owner.
4. Warranty information is required for all materials supplied by the Contractor.
5. Damage by vandals, fire, traffic accidents or "acts of God" is excluded from warranty.

4.1.6. Schedule Requirements

The contract period is expected to begin on or around August 11, 2017 and extend through the close-out of the project in fall of 2017.

SELECTION NOTIFICATION	August 10, 2017
CONTRACT EXECUTED	August 10, 2017
BEGIN CONSTRUCTION	August 24, 2017
COMPLETE CONSTRUCTION	October 30, 2017
OPM’S ACCEPTANCE OF SYSTEM	November 1, 2017

5. Proposal Requirements

Each Proposal must answer each of the following sections to be considered for evaluation. If a Respondent fails to meet any material terms, conditions, requirements or procedures, its response may be deemed unresponsive and disqualified.

5.1. Company Information

1. Provide your company information, including legal name, state of incorporation, year of incorporation, type of entity, all contact information, and a list of affiliated companies or other names you have done business as.
2. Please identify whether you are currently authorized to operate in the State of Maine and whether you maintain a physical presence within the state.

3. What other states or locations, if any, do you maintain an office or operations?
4. How many employees comprise your workforce: a) full time; b) part time; c) contract?
5. What are the functional groups within your company?
6. Please identify any awards or recognition received by your company in the past 3 years.
7. Please list any licenses, certifications or accreditations awarded to your company.
8. Are you currently under contract or negotiations for a contract with the State of Maine? Any other state or municipality? Please list.
9. If selected as a vendor of choice, how soon can your company begin providing construction services to the Owner?
10. Please provide evidence that you are capable of complying with the bond and insurance requirements of this project, as more specifically set forth in the Owner-Contractor Agreement attached as Appendix A.

## 5.2. Industry Experience

Please provide the following for your company and all Sub-Contractors:

1. Please provide three (3) customer/client references including name, email, address, project timeline, and description of work.
2. Please list the training certifications that your technicians hold and any experience with standards such as NECA 301 Standard and OTDR/loss testing.
3. Please provide your company's safety program, as well as any OSHA reportables within the past 3 years.
4. Which activities of Scope B will your company perform? Which activities will your company Sub-Contract out?
5. Are your technicians trained and experienced with NECA 301 standards?
6. Are your technicians trained in OTDR/Loss testing?
7. Do your technicians hold certifications for splicing?

## 5.3. Bond Requirements and Insurance

Proof of insurance is required upon notification of award. The successful bidder shall provide proof of worker's compensation insurance, comprehensive general liability insurance, and comprehensive automobile insurance in their response, in the amounts required by the Owner-Contractor Agreement attached as Appendix A.

## 5.4. Conformance to Requirements

Please identify how your company will conform to all requirements as identified in Section 5. Please identify any subsections you do not believe you can or will conform to. Please identify any subsections in Sections 4, 5 or 6 and Appendices A through J that you do not believe are necessary or will change your proposal in scope, performance or price.

## 5.5. Price

Please provide a firm fixed price for the work described in this RFP. Respondents must provide their unit price labor costs for installation of the items included in the Bill of Materials.

The Town of Islesboro is a municipal corporation organized and existing under the laws of the State of Maine. Our sales tax exemption number will be provided to the selected Contractor(s).

#### 5.6. Value Engineering

If able, Respondents are invited to submit an alternative design on all or part of this RFP for the Owner's review that provides equal or greater function at lower cost.

#### 5.7. Project Management

1. List what primary tools, equipment, software and hardware you use for Contractor project management.
2. Identify how you make your work effective and efficient.
3. Describe your recommended project management approach for coordination and communication.

#### 5.8. Schedule Requirements

Describe the schedule you will meet for this project. Also, specifically describe how you intend to meet that schedule and what kind of guarantees or assurances you can provide.

#### 5.9. Approvals and Certifications

Affirm that your proposal to this RFP will be valid for all parts of the network identified even if some of that work must be completed by a Sub-Contractor.

#### 5.10. Safety

The Contractor shall provide all safeguards, safety devices and protective equipment and take any other needed actions to reasonably protect the public and private property connection with the performance of the work covered by the contract.

The Contractor shall take the necessary precautions and bear the sole responsibility for the safety of the methods employed in performing the work.

#### 5.11. Warranty

Please describe how you will meet the minimum warranty requirements specified and appropriate within this document. Description must meet minimum requirements but additional items or lengths of time will be viewed favorably.

## 6. Proposal Evaluation Criteria

The Owner will review the RFP responses in accordance with the submittal requirements and using the criteria generally described as follows. Criteria are not necessarily listed in order of importance.

1. The thoroughness and comprehensiveness of each response.

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2. The ability to meet the construction requirements, installation and testing requirements.
3. The qualifications, experience and knowledge of the Respondent and the proposed project personnel.
4. Ability to meet schedules and deadlines.
5. Price of the work requested under this RFP.
6. Familiarity with the proposed project areas or areas of similar geography.
7. Ability to work in a safe manner.
8. Ability to control and minimize costs as demonstrated in the response and through experience in prior projects.
9. Agreement to conform, or have Sub-Contractors conform, to Appendix A: Owner-Contractor Agreement.
10. Compliance with Sections 3.2.2 – Business Registration and Sections 3.5 Standard Terms and Conditions.

## Appendix A: Owner-Contractor Agreement

### AGREEMENT

THIS AGREEMENT is made this \_\_\_\_\_ day of \_\_\_\_\_, 2017, by and between the **INHABITANTS OF THE TOWN OF ISLESBORO**, a municipal corporation existing under the laws of the State of Maine and located in the County of Waldo, State of Maine (hereinafter "OWNER") and , a Maine [type of entity] with a principal place of business in \_\_\_\_\_, Maine (hereinafter "CONTRACTOR").

### WITNESSETH:

In consideration of the mutual covenants and conditions contained herein, the OWNER and the CONTRACTOR agree as follows:

#### 1. SCOPE OF THE WORK

The CONTRACTOR shall furnish all of the materials and perform all of the work described as Scope B in the Construction Services for Fiber Optic Broadband Infrastructure Request for Proposals dated \_\_\_\_\_, 2017 and as amended through \_\_\_\_\_, 2017 by Addenda Nos. \_\_\_\_ (the "RFP") and the Drawings dated \_\_\_\_\_ (the "Drawings") provided to the CONTRACTOR by the OWNER (collectively the "Work"). The RFP, the Drawings, and the CONTRACTOR's Response to the RFP (the "RFP Response") (hereinafter collectively the "Project Manual") are incorporated herein and made a part hereof by reference, and the CONTRACTOR covenants that it shall do everything required by this Agreement, the conditions of this Agreement, and the Project Manual in return for payment as provided herein. The restatement in this Agreement of any of the terms of said Project Manual shall not be deemed to waive any terms not so restated. To the extent that there is any conflict between the RFP and the RFP Response, the terms of the RFP shall control. To the extent that there is any conflict between the Project Manual and this Agreement, the terms of this Agreement shall control.

#### 2. CONTRACTOR OBLIGATIONS

The CONTRACTOR warrants:

- a. That it will furnish all vehicles, materials, personnel, tools and equipment, except as otherwise specified herein, and do everything necessary and proper to satisfactorily perform the Work required by this Agreement.
- b. That it is financially solvent, is experienced in and competent to perform the Work and is able to furnish the vehicles, materials, personnel, tools and equipment to be furnished by it.
- c. That it is familiar with all federal, state and local statutes, laws, rules, regulations, ordinances and orders that may in any way affect the Work.
- d. That it has carefully examined the Project Manual, this Agreement and the site of the Work and has conducted its own investigation of the nature and location of the Work, the character of equipment



and personnel needed to perform the Work and all conditions that may in any way affect the performance of the Work.

- e. That any increase in CONTRACTOR'S costs during the term of this Agreement shall be the sole responsibility of the CONTRACTOR.
- f. The Work shall conform to the 2014 Edition of the National Electrical Code, National Electrical Safety Code and all state and local codes and ordinances. ANSI/TIA/EIA Standards shall be adhered to during all installation activities.
- g. That materials and equipment furnished under this Agreement will be of good quality and new unless otherwise required or permitted by the Project Manual and this Agreement, that the Work will be free from defects not inherent in the quality required or permitted, and that the Work will conform to the requirements of the Project Manual and this Agreement. Work not conforming to these requirements, including substitutions not properly approved and authorized, may be considered defective. The CONTRACTOR's warranty excludes remedy for damage or defect caused by abuse, modifications not executed by the CONTRACTOR, improper or insufficient maintenance, improper operation, or normal wear and tear and normal usage. If required by the Owner's Project Manager, the CONTRACTOR shall furnish satisfactory evidence as to the kind and quality of materials and equipment.

### 3. COMPLETION DATE

The work to be performed under this Agreement shall be commenced by \_\_\_\_\_, 2017 and substantially completed on or before \_\_\_\_\_, 2017. Due to the difficulty of calculating damages for late completion, liquidated damages in the amount of \$100.00 per day for late completion shall be awarded to the OWNER for delay in Substantial Completion not otherwise excused or permitted under this Agreement.

Substantial Completion is the stage in the progress of the Work when the Work is sufficiently complete in accordance with the Project Manual and this Agreement so that the OWNER can occupy or utilize the Work for its intended use.

### 4. CONTRACT PRICE

The OWNER shall pay the CONTRACTOR for the performance of this Agreement the sum of \_\_\_\_\_ Dollars (\$ \_\_\_\_\_) in accordance with the terms and conditions set forth in Sections 17, 18 and 19 of this Agreement.

### 5. PERFORMANCE AND PAYMENT BONDS

The CONTRACTOR shall furnish to the OWNER at the time of the execution of this Agreement a performance bond and a separate labor and material payment bond, each in the amount of \$\_\_\_\_\_ [contract price] executed by a surety company satisfactory to the OWNER, guaranteeing the faithful performance of this Agreement and payment of obligations arising hereunder by the CONTRACTOR, including the guarantee period and free and clear of any and all liens, attachments and encumbrances.

## 6. GUARANTEE

The CONTRACTOR warrants to the OWNER that materials and equipment furnished under the Agreement will be of good quality and new unless otherwise required or permitted by the Project Manual and this Agreement, that the Work will be free from defects not inherent in the quality required or permitted, and that the Work will conform to the requirements of the Project Manual and this Agreement. Work not conforming to these requirements, including substitutions not properly approved and authorized, may be considered defective. The CONTRACTOR's warranty excludes remedy for damage or defect caused by abuse, modifications not executed by the CONTRACTOR, improper or insufficient maintenance, improper operation, or normal wear and tear and normal usage. If required by the OWNER, the CONTRACTOR shall furnish satisfactory evidence as to the kind and quality of materials and equipment. The CONTRACTOR and the subcontractors shall guarantee their work against any defects in workmanship and materials for a period of one year from the date of Substantial Completion of all of the Work, and agrees to repair or replace at no cost or expense to the OWNER all work, materials and fixtures at any time during said one year period. The OWNER shall give notice to CONTRACTOR promptly after discovery of the condition. If the CONTRACTOR fails to correct nonconforming Work within a reasonable time after receipt of notice from the OWNER, the OWNER may, without prejudice to other remedies the OWNER may have, correct such deficiencies, and the CONTRACTOR shall pay the cost to the OWNER.

## 7. PERMITS AND LICENSES

Permits and licenses necessary for the prosecution of the work shall be secured by the CONTRACTOR.

## 8. OWNER'S RIGHT TO TERMINATE CONTRACT

Without prejudice to any other right or remedy, the OWNER may terminate this Agreement for cause by providing the CONTRACTOR and its surety with seven (7) days' written notice of termination. For purposes of this Agreement, cause includes, but is not limited to: the adjudication of the CONTRACTOR as a bankrupt; the making of a general assignment by the CONTRACTOR for the benefit of its creditors; the appointment of a receiver because of the CONTRACTOR's insolvency; the CONTRACTOR's persistent or repeated refusal or failure, except for cases in which extension of time is provided, to supply enough properly skilled workers or proper materials; the CONTRACTOR's persistent disregard of federal, state or local statutes, laws, rules, regulations, codes, ordinances or orders; and the CONTRACTOR's substantial violation of any provisions of this Agreement. In the event of a termination for cause, the OWNER may take possession of the premises and of all materials, tools and appliances thereon and finish the work by whatever method it may deem expedient. In such case the CONTRACTOR shall not be entitled to receive any further payment until the work is finished. If the unpaid balance of the Contract Price shall exceed the expense of finishing the work, including compensation for additional design, managerial and administrative services, such excess shall be paid to the CONTRACTOR. If such expense shall exceed such unpaid balance, the CONTRACTOR shall pay the difference to the OWNER.

## 9. INSURANCE

The OWNER shall purchase and maintain builder's risk insurance. The CONTRACTOR shall purchase from and maintain in a company or companies lawfully authorized to do business in Maine

such insurance as will protect the CONTRACTOR from claims set forth below which may arise out of or result from the CONTRACTOR's operations under this Agreement and for which the CONTRACTOR may be legally liable, whether such operations be by the CONTRACTOR or by a subcontractor or by anyone directly or indirectly employed by any of them, or by anyone for whose acts any of them may be liable. The CONTRACTOR shall obtain and maintain throughout the term of this Agreement at no expense to the OWNER the following insurance coverages written for not less than the following limits, or greater if required by law:

- a. Commercial General Liability Insurance including coverage for Premises-Operations, Independent Contractors' Protective, Products-Completed Operations, Contractual Liability, Personal Injury and Broad Form Property Damage (including coverage for Explosion, Collapse and Underground hazards) in the following amounts:

- \$1 million Each Occurrence
- \$2 million General Aggregate
- \$1 million Personal and Advertising Injury
- \$1 million Products - Completed Operations Aggregate
- \$5 million Umbrella (Each Occurrence and General Aggregate)

The policy shall be endorsed to have the General Aggregate apply to this project only. Products and Completed Operations insurance shall be maintained for a minimum period of at least one (1) year after either 90 days following Substantial Completion or final payment, whichever is earlier. The Contractual Liability insurance shall include coverage sufficient to meet the obligations in Section 10.

- b. Automobile Liability Insurance (owned, non-owned and hired vehicles) for bodily injury and property damage in the following amount:

- \$1 million Each Accident.

- c. Workers' Compensation Insurance in such amount as required by Maine law and Employer's Liability Insurance, as necessary, as required by Maine law. In case any class of employees engaged in hazardous work under this Agreement is not protected under the Worker's Compensation Act, the CONTRACTOR shall, at its own expense, provide for the protection of its employees not otherwise protected.
- d. All required insurance coverages to work on utility poles, lines and within the communication space owned by Central Maine Power and FairPoint.
- e. All such insurance policies shall name the OWNER and its officers, agents and employees as additional insureds, except that for purpose of workers' compensation insurance, the CONTRACTOR instead may provide a written waiver of subrogation rights against the OWNER. The CONTRACTOR, prior to commencement of work under this Agreement shall deliver to the OWNER certificates evidencing such insurance coverages, which certificates shall state that the CONTRACTOR must provide written notice to the OWNER at least thirty (30) days prior to cancellation, non-renewal, material modification or expiration of any policies, evidenced by return receipt of United States Certified Mail, notwithstanding anything herein to the contrary. Replacement certificates shall be delivered to the OWNER prior to the effective date of cancellation, termination, material modification or expiration

of any such insurance policy. The CONTRACTOR shall not commence work under this Agreement until it has obtained all insurance coverages required under this subparagraph and such insurance policies have been approved by the OWNER. All such insurance policies shall have a retroactive date which is the earlier of the date of this Agreement between the parties or the CONTRACTOR's commencement of services thereunder.

#### 10. INDEMNIFICATION

The CONTRACTOR shall indemnify and hold harmless the OWNER, its officers, agents, and employees, from and against any and all claims, damages, losses and expenses, including but not limited to attorneys' fees, arising out of or resulting from performance of the Work, provided that such claim, damage, loss or expense is attributable to bodily injury, sickness, disease or death, or to injury to or destruction of tangible property (other than the Work itself), resulting from the fault of, or any negligent acts or omissions or willful misconduct of the CONTRACTOR, a subcontractor, anyone directly or indirectly employed by them or anyone for whose acts they may be liable, regardless of whether or not such claim, damage, loss or expense is caused in part by a party indemnified hereunder. Such obligation shall not be construed to negate, abridge, or reduce other rights or obligations of indemnity which would otherwise exist as to a party or person described in this Section 10.

In claims against any person or entity indemnified under this Section 10 by an employee of the CONTRACTOR, a subcontractor, anyone directly or indirectly employed by them or anyone for whose acts they may be liable, the indemnification obligation under Section 10 shall not be limited by a limitation on amount or type of damages, compensation or benefits payable by or for the CONTRACTOR or a subcontractor under workers' compensation acts, disability benefit acts or other employee benefit acts.

The provisions of this Section 10 shall survive the termination or expiration of this Agreement.

#### 11. LIENS

Neither the final payment nor any part of the retained percentage shall become due until the CONTRACTOR, if required by the OWNER, shall deliver to the OWNER a complete release of all liens arising out of this Agreement, or receipts in full in lieu thereof and, if required in either case, an affidavit that so far as it has knowledge or information the releases and receipts include all the labor and material for which a lien could be filed, but the CONTRACTOR may, if any subcontractor refuses to furnish a release or receipt in full, furnish a bond satisfactory to the OWNER to indemnify it against any lien. If any lien remains unsatisfied after all payments are made, the CONTRACTOR shall refund to the OWNER all moneys that the latter may be compelled to pay in discharging such a lien, including all costs and a reasonable attorney's fee.

#### 12. ASSIGNMENT

Neither party to the Agreement shall assign this Agreement or sublet it as a whole without the written consent of the other, nor shall the CONTRACTOR assign any moneys due or to become due to it hereunder, without the previous written consent of the OWNER.

#### 13. SUBCONTRACTS

By appropriate agreement, written where legally required for validity, the CONTRACTOR shall require each subcontractor, to the extent of the Work to be performed by the subcontractor, to be bound to the CONTRACTOR by terms of the Project Manual and this Agreement, and to assume toward the CONTRACTOR all the obligations and responsibilities, including the responsibility for safety of the subcontractor's Work, which the CONTRACTOR, by these documents, assumes toward the OWNER. Each subcontract agreement shall preserve and protect the rights of the OWNER under the Project Manual and this Agreement with respect to the Work to be performed by the subcontractor so that subcontracting thereof will not prejudice such rights, and shall allow to the subcontractor, unless specifically provided otherwise in the subcontract agreement, the benefit of all rights, remedies and redress against the CONTRACTOR that the CONTRACTOR, by the Project Manual and this Agreement, has against the OWNER. Where appropriate, the CONTRACTOR shall require each subcontractor to enter into similar agreements with sub-subcontractors. The CONTRACTOR shall make available to each proposed subcontractor copies of the Project Manual and this Agreement to which the subcontractor will be bound. Subcontractors will similarly make copies of applicable portions of such documents available to their respective proposed sub-subcontractors.

#### 14. USE OF PREMISES

The CONTRACTOR shall confine its apparatus, the storage of materials and the operations of its workers to limits indicated by law, ordinances and permits and shall not otherwise unreasonably encumber the premises with its materials. If any part of the project is completed and ready for use, the OWNER may, by written and mutual consent, without prejudice to any of its rights or the rights of the CONTRACTOR, enter in and make use of such completed parts of the project provided such occupancy or use is consented to by the insurer providing property insurance. Immediately prior to such partial occupancy or use, the OWNER, CONTRACTOR and Owner's Project Manager shall jointly inspect the area to be occupied or portion of the Work to be used in order to determine and record the condition of the Work. Such use or occupancy shall in no case be construed as an acceptance of Work or materials not complying with the requirements of the Project Manual and this Agreement.

#### 15. CLEANING UP

The CONTRACTOR shall at all times keep the premises free from accumulation of waste materials or rubbish caused by its employees or work, and at the completion of the work it shall remove all its rubbish from and about the project, and all its tools, scaffolding and surplus materials and shall leave its work "broom-clean" or its equivalent, unless more exactly specified. In case of dispute, the OWNER may remove the rubbish and charge the cost to the CONTRACTOR.

#### 16. CHANGE ORDERS

A Change Order is a written instrument prepared by the Owner's Project Manager and signed by the OWNER, CONTRACTOR and Owner's Project Manager, stating their agreement upon all of the following:

- (a) change in the Work;
- (b) the amount of the adjustment, if any, in the Contract Price; and
- (c) the extent of the adjustment, if any, in the Completion Date.

A Change Order shall be based upon agreement among the OWNER, CONTRACTOR and Owner's Project Manager; provided, however, that no written Change Order adjusting the Contract Price or the

Completion Date shall be effective unless and until approved by formal vote of the OWNER's Board of Selectmen.

#### 17. PROGRESS PAYMENTS

Based upon Applications for Payment submitted to the Owner's Project Manager by the CONTRACTOR and Certificates for Payment issued by the Owner's Project Manager, the OWNER shall make progress payments on account of the Contract Price to the CONTRACTOR as follows:

On or before the 30<sup>th</sup> day of each month following commencement of construction, the CONTRACTOR shall submit to the OWNER an itemized pay requisition outlining the percentage and dollar amount of work completed. Upon receipt of said document, the Owner's Project Manager shall inspect the premises and make a payment recommendation to the OWNER. Upon the OWNER's approval of the Owner's Project Manager's payment recommendation, payment of the approved amount less five percent (5%) retainage shall be made by the OWNER. Provided that the OWNER has received the itemized pay requisitions by the 30<sup>th</sup> of the month, the OWNER shall pay the CONTRACTOR on or before the 15<sup>th</sup> of the following month. All retainage shall be held until the OWNER's final acceptance of the work.

All Applications for Payment shall include, in addition to other required items, (a) lien waivers, in form and substance sufficient as a matter of law to waive all liens or claims of liens for all Work covered by the Application for Payment, executed by (i) the CONTRACTOR, and (ii) each subcontractor or materialman to be paid an amount in excess of \$500 out of the progress payment, and providing that such lien waiver shall become effective upon payment of the amount requested for payment to such party under the Application for Payment; and (b) evidence reasonably adequate to demonstrate that previous progress payments have been disbursed by the CONTRACTOR to subcontractors and materialmen in accordance with the Applications therefor.

#### 18. PUNCH LIST/SUBSTANTIAL COMPLETION

When the CONTRACTOR considers that the Work, or a portion thereof which the OWNER agrees to accept separately, is substantially complete, the CONTRACTOR shall prepare and submit to the Owner's Project Manager a comprehensive list of items to be completed or corrected prior to final payment ("punch list"). Failure to include an item on such punch list does not alter the responsibility of the CONTRACTOR to complete all Work in accordance with the Project Manual and this Agreement.

Within seven days of receipt of the CONTRACTOR's list, the Owner's Project Manager will, in consultation with the OWNER's designee, make an inspection to determine whether the Work or designated portion thereof is substantially complete. If the Owner's Project Manager's inspection discloses any item, whether or not included on the CONTRACTOR's list, which is not sufficiently complete in accordance with the Project Manual and this Agreement so that the OWNER can occupy or utilize the Work or designated portion thereof for its intended use, the CONTRACTOR shall, before issuance of the Certificate of Substantial Completion, complete or correct such item upon notification by the Owner's Project Manager. In such case, the CONTRACTOR shall then submit a request for another inspection by the Owner's Project Manager to determine Substantial Completion. During the Owner's Project Manager's initial inspection, the Owner's Project Manager, in consultation with the OWNER's designee, shall prepare a list of any unfinished work not already included on the CONTRACTOR's list that must be completed prior to Final Completion. Any item not included either on the CONTRACTOR's list or the Owner's Project Manager's list shall be treated as warranty work.

When the Work or designated portion thereof is substantially complete, the Owner's Project Manager will prepare a Certificate of Substantial Completion which shall establish the date of Substantial Completion, shall establish responsibilities of the OWNER and CONTRACTOR for security, maintenance, heat, utilities, damage to the Work and insurance, and shall fix the time within which the CONTRACTOR shall finish all items on the list accompanying the Certificate. Warranties required by this Agreement shall commence on the date of Substantial Completion of the Work or designated portion thereof unless otherwise provided in the Certificate of Substantial Completion.

The Certificate of Substantial Completion shall be submitted to the OWNER and CONTRACTOR for their written acceptance of responsibilities assigned to them in such Certificate. Upon such acceptance and consent of surety, if any, the OWNER shall make payment of retainage applying to such Work or designated portion thereof. Such payment shall be adjusted for Work that is incomplete or not in accordance with the requirements of the Project Manual and this Agreement.

#### 19. FINAL PAYMENT

Final payment, constituting the entire unpaid balance of the Contract Price, shall be made by the OWNER to the CONTRACTOR when (1) the Work has been completed and the Agreement has been fully performed by the CONTRACTOR except for the CONTRACTOR's responsibility to correct nonconforming Work, as provided in Section 6, and to satisfy other requirements, if any, which necessarily survive final payment; (2) a final Application for Payment has been submitted by the CONTRACTOR; and (3) a final Certificate for Payment has then been issued by the Owner's Project Manager; such final payment shall be made by the OWNER not more than thirty (30) days after the issuance of the Owner's Project Manager's final Certificate for Payment.

Neither final payment nor any remaining retained percentage shall become due until the CONTRACTOR submits to the Owner's Project Manager with the final Application for Payment: (1) an affidavit that payrolls, bills for materials and equipment, and other indebtedness connected with the Work for which the OWNER or the OWNER's property might be responsible or encumbered (less amounts withheld by OWNER) have been paid or otherwise satisfied; (2) a certificate evidencing that insurance required by this Agreement to remain in force after final payment is currently in effect and will not be cancelled or allowed to expire until at least thirty (30) days' prior written notice has been given to the OWNER; (3) a written statement that the CONTRACTOR knows of no substantial reason that the insurance will not be renewable to cover the period required by this Agreement; (4) consent of surety, if any, to final payment; and (5) documents establishing that all subcontractors and suppliers have waived their liens or that the period for asserting such liens has expired. If a subcontractor refuses to furnish a release or waiver required by the OWNER, the CONTRACTOR shall furnish a bond satisfactory to the OWNER to indemnify the OWNER against such lien. If the subcontractor files a lien, the CONTRACTOR shall furnish a bond satisfactory to the OWNER to indemnify against such lien. If the subcontractor has not filed a lien, and the CONTRACTOR has provided the OWNER with a payment bond for the Project in an amount sufficient to cover the Subcontractor's claim, then the CONTRACTOR shall not be required to provide any additional security.

#### 20. OWNERSHIP OF DOCUMENTS

All drawings, notes, documents, plans, and specifications or other material to be developed under this Agreement shall become the property of the OWNER and be promptly delivered to the OWNER upon the completion of work under this Agreement or sooner upon the OWNER's request. The

CONTRACTOR shall be responsible for the protection and/or replacement of any work or materials in its possession, including work or materials provided to the CONTRACTOR by the OWNER. The OWNER agrees that it will not use the construction plans and specifications developed under this Agreement for any project other than the project specified herein without the written consent of the CONTRACTOR, which consent shall not be unreasonably withheld, conditioned or delayed.

21. FORCE MAJEURE

Provided such party gives written notice to the other of such event, a party shall not be liable for its failure to perform its respective obligations under this Agreement, if prevented from so doing by any cause beyond the reasonable control of such party such as, but not limited, to strikes, lockouts, or failure of supply or inability by the exercise of reasonable diligence, to obtain supplies, parts, or employees necessary to perform such obligations, or because of acts of God, war or other emergency. The time within which such obligations shall be performed shall be extended for a period of time equivalent to the delay from such cause.

22. NON-WAIVER

Except as expressly provide in this Agreement, the failure or waiver, or successive failures or waivers on the part of either party hereto, in the enforcement of any paragraph or provision of this Agreement shall not render the same invalid nor impair the right of either party hereto, its successors or permitted assigns, to enforce the same in the event of any subsequent breach thereof.

23. NOTICES

Notices hereunder shall be deemed sufficient if sent by U.S. mail, certified, as follows:

TO	OWNER:	Town Manager Town of Islesboro P.O. Box 76 Islesboro, ME 04848-0076
----	--------	--

TO CONTRACTOR:	_____
	_____
	_____
	_____

24. REMEDIES

(a) All disputes arising in connection with or under this Agreement where no party's disclosed claim or counterclaim exceeds \$75,000, exclusive of any claimed interest, attorneys' fees, arbitration fees and costs, shall be finally resolved by binding arbitration administered by the American Arbitration Association under its Construction Industry Arbitration Rules/Fast Track Procedures. Unless otherwise agreed in writing by the parties, the proceedings shall be held in Waldo County, Maine. Any such decision rendered by the arbitrator shall be final, binding, and non-appealable.

(b) All other disputes including, without limitation, any claims for non-monetary relief such as injunctive relief, shall be resolved first by mandatory, non-binding mediation with a neutral agreed upon by the parties and then, if necessary, by the filing of a civil action in Maine Superior Court (Waldo



County). This dispute resolution mechanism shall be binding upon the successors, assigns, foreclosing mortgage and any trustee or receiver of any Party.

This Agreement is made and shall be construed under the laws of the State of Maine except any law that purports to apply the substantive law of any other state, or jurisdiction. Except as otherwise expressly agreed by the parties in writing, exclusive venue for any such civil action shall be in Maine Superior Court (Waldo County).

25. COMPLIANCE WITH APPLICABLE LAWS

The CONTRACTOR agrees that it and its subcontractors shall comply with all applicable federal, state and local statutes, laws, rules, regulations, codes, ordinances and orders in the performance of work under this Agreement.

26. EXTENT OF AGREEMENT

This Agreement (and the Project Manual incorporated into this Agreement) represents the entire and integrated Agreement between OWNER and the CONTRACTOR and supersedes all prior negotiations, representations, or agreements, either written or oral. This Agreement may be amended only by written instrument signed by both the OWNER and the CONTRACTOR.

IN WITNESS WHEREOF, the parties hereto have executed this Agreement on the day and year first above written.

OWNER - INHABITANTS OF THE  
TOWN OF ISLESBORO

\_\_\_\_\_  
Witness

By: \_\_\_\_\_  
Janet Anderson  
Its Town Manager, duly authorized

CONTRACTOR - \_\_\_\_\_

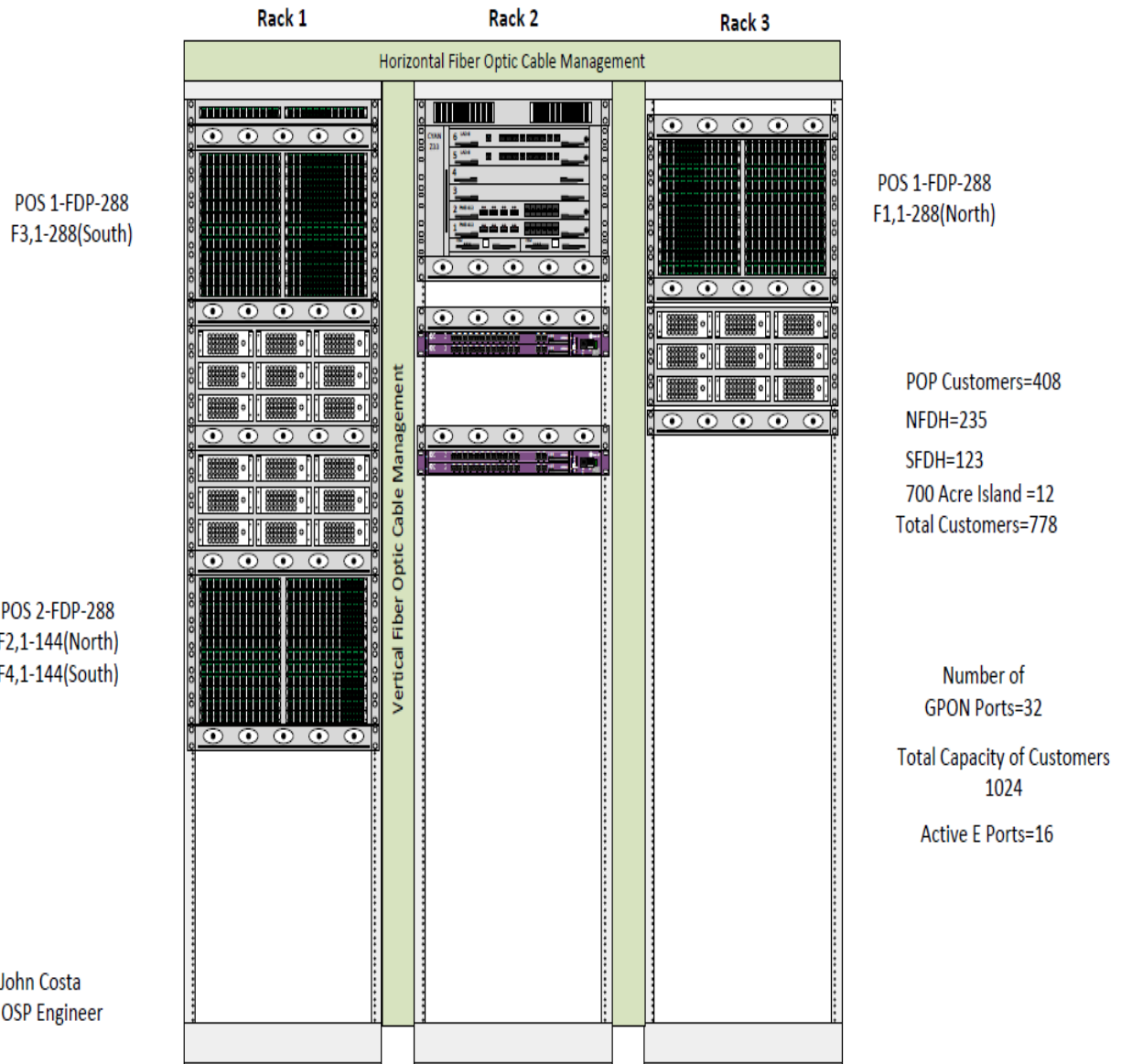
\_\_\_\_\_  
Witness

By: \_\_\_\_\_  
\_\_\_\_\_  
Its \_\_\_\_\_, duly authorized

## Appendix B: Islesboro POP Relay Rack Design

December 16, 2015

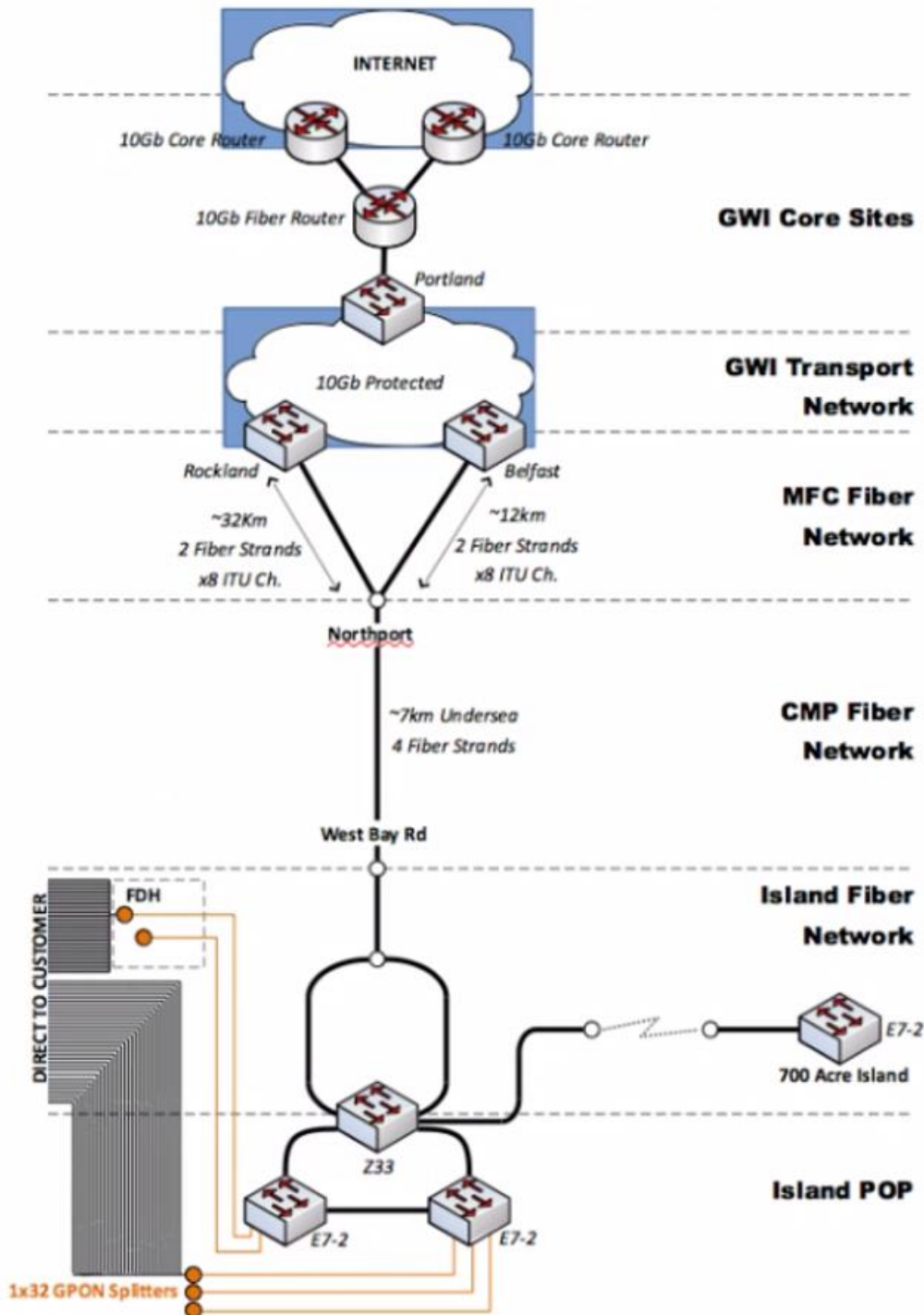
### Islesboro POP Relay Rack Design



John Costa  
 Sr. OSP Engineer



## Appendix C: Interconnection with GWI's Network



## Appendix D: Network Equipment Bill of Materials

Part	Description	Manufacturer or equivalent	Part # or equivalent	Quantity
<b>POP</b>				
Z33 GSP	Z33 GSP	Ciena	001-0002-00	1
Management Module	LINECARD AMB (Management Module)	Ciena	950-0004-00	3
LAD-8	LAD-8	Ciena	800-0020-03	2
PME-412	PME-412 --> Switch line card w/ 4xXFP and 12xSFP	Ciena	800-0026-01	2
XFP & Jumper Kit	XFP, ITU CH 30 AND FIBER JUMPER KIT	Ciena	002-0046-00	2
10G XFP SR MM	XFP, 10G-SR Multimode	Ciena	280-0056-00	2
SFP, 1000BASE-LX, 10KM	SFP, 1000BASE-LX, 10KM	Ciena	280-0030-00	2
E7-2 Shelf	E7-2 Field Install Package (CO & ODC/RT): Shelf with Blank Card, FTA, and Field installation Kit	Calix	000-00372	4
E7-2 GPON-8 card	E7-2 GPON-8 (8x GPON OIM, 4x GE SFP, 2x 10GE SFP+)	Calix	100-03006	5
Copper cable SFP	Direct Attach SFP/SFP+ copper cable, 0.5 m, 30AWG, I-Temp	Calix	100-01424	4
10GE SFP+ 300m	10GE SFP+, Multi-Mode dual fiber transceiver, 300m, 850nm, LC, C-temp	Calix	100-01515	2
GPON SFP	GPON SFP OIM, Class B+, 1490/1310nm Single FiberTransceiver, C-Temp (CO), C- & E-Series	Calix	100-01782	40
1GE BIDI SFP, 20km	1GE BIDI SFP, Single Mode single fiber Downstream transceiver, 20Km, Tx1490nm, LC, I-Temp	Calix	100-01669	16
CAP-Software	Calix Advantage Program - Entry Tier - North America - Certified	Calix	110-00881	1
Consumer	Compass Consumer Connect -	Calix	130-00057	12

REQUEST FOR PROPOSALS  
RFP No. ISL-2017-01  
CONSTRUCTION SERVICES FOR FIBER OPTIC BROADBAND INFRASTRUCTURE

Connect-Software	Monthly Service Charge for up to 1000 Devices			
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<b>700 Acre Island</b>				
E7-2 Shelf	E7-2 Field Install Package (CO & ODC/RT): Shelf with Blank Card, FTA, and Field installation Kit	Calix	000-00372	1
E7-2 GPON-8 card	E7-2 GPON-8 (8x GPON OIM, 4x GE SFP, 2x 10GE SFP+)	Calix	100-03006	1
GPON SFP OIM C&E series	GPON SFP OIM, Class B+,1490/1310nm Single Fiber Transceiver, I-Temp (RT), C- & E-Series	Calix	100-01783	1
1GE SFP, 10km	1GE SFP, Single Mode dual fiber transceiver, 10Km, 1310nm, LC, I-Temp	Calix	100-01662	2
IDU Interface – 2Km	Horizon Quantum Pluggable IDU Fiber Interface, SX (2 Km)	Horizon Quantum	A-OPT-PLG-FIB-SX-HQ	1

## Appendix E: Point of Presence (POP) Installation Standards Guide

### 1. Introduction and Scope

#### 1.1. Introduction

- 1.1.1. This Appendix describes the Environmental and Installation Requirements, including the Cabling, Powering and Grounding options for Telecommunications Equipment to be placed in the Town of Islesboro Broadband Network Point of Presence (POP) locations.
- 1.1.2. Work at POPs consists of network cabling and equipment installation.

#### 1.2. Reason for Issuance

- 1.2.1. This publication is being issued primarily to define installation guidelines for telecommunications equipment and cabling installation at POP locations.
- 1.2.2. The guidelines and standards referenced herein are intended to allow the Network Equipment Vendor to properly evaluate and make ready POP facility locations and to produce “detailed” Method of Procedure or installation procedure (MOP) documents resulting in consistent site builds and related documentation.
- 1.2.3. This Appendix may be revised or updated at any time and for any reason, including but not limited to, conformity with standards promulgated by various institutes, governmental or regulatory agencies; advances in technology; or to reflect changes in the design of equipment, techniques, or procedures described or referred to herein. Liability to anyone arising out of use or reliance upon any information set forth herein is expressly disclaimed, and no representation or warranties, expressed or implied, are made with respect to the accuracy or utility of any information set forth herein.
- 1.2.4. This Appendix is not to be construed as a suggestion to any manufacturer to modify or change any of its products, nor does this publication represent any commitment to purchase any specific products or services.

#### 1.3. Items Not Covered

- 1.3.1. This publication does not include specifications for active network components, topologies and/or depicting network architectures.
- 1.3.2. This publication does not include guidelines for acceptance testing or any other specific test plans that may be associated with the work being performed.

### 2. General Requirements

#### 2.1. General

- 2.1.1. It shall be the responsibility of the Installer to have a current copy of this Appendix on site and available for use at all times during the installation.

- 2.1.2. No work shall start or be performed without a properly approved MOP. A copy of the MOP shall be posted in the work area.

## 2.2. Application of Codes, Standards, Regulations and Guidelines

- 2.2.1. The following Codes, Standards and Regulations shall be applied in the following order of precedence:
  1. Local and/or national building and fire and safety codes.
  2. Vendor and Manufacturer requirements for installation.
  3. This Publication and the industry codes, standards and publications referenced herein.
  4. Questions and/or conflicts discovered during the application of the Codes, Standards and Regulations referenced herein shall be referred to the OPM.
- 2.2.2. All standards, guidelines, technical specifications and deliverables as defined in the RFP shall apply. The following standards and guidelines are intended to clarify the Minimum Technical Specifications, or to supplement those standards by defining a particular standard practice when multiple options are available. Effort has been made to insure that any technical specifications, standards or guidelines outlined in this Appendix conform to the technical specifications of the RFP. In the event the Installer determines that a conflict does exist, the OPM must be notified for clarification and/or resolution.
- 2.2.3. Applicable Local, State and Federal Electrical and Building Codes, Fire and Safety Regulations, Standards and Guidelines shall govern the installation practices and materials used in the construction of POI telecommunications facilities.
- 2.2.4. All equipment and materials used shall be Underwriters' Laboratories (UL) listed and labeled.
- 2.2.5. All installation practices must conform to the Equipment Manufacturer's requirements for their network elements.
- 2.2.6. The latest editions and amendments of the following codes, standards and publications are minimum requirements:
  - Local Municipal Code related to Electrical Inspections (Electrical Code)
  - NAFPA 70 National Electrical Code (NEC)
  - NESC 2012 National Electrical Safety Code
  - ANSI/TIA/EIA-568-A, Commercial Building Telecommunication Cabling Standard
  - ANSI/TIA/EIA-568-A-2, Corrections and Additions to TIA/EIA-568-A-2
  - ANSI/TIA/EIA-568-A-3, Addendum No. 3 to Tia/EIA-568-A
  - ANSI/TIA/EIA-568-B.1, Commercial Building Telecommunications Cabling Standard, Part 1: General Requirements
  - ANSI/TIA/EIA-568-B.3, Optical Fiber Cabling Components Standard
  - ANSI/TIA/EIA-569-A, Commercial Building Standard for Telecommunications Pathways and Spaces
  - ANSI/TIA/EIA-570, Residential and Light Commercial Telecommunications Wiring Standard
  - ANSI/TIA/EIA-598-A, Optical Fiber Cable Color Coding
  - ANSI/TIA/EIA-606(A), The Administration Standard for the Telecommunications Infrastructure of Commercial Buildings
  - ANSI/TIA/EIA-607(A), Commercial Building Grounding and Bonding Requirements for Telecommunications

- ANSI/TIA/EIA-526-7, Measurement of Optical Power Loss of Installed Single-Mode Fiber Cable Plant
- ANSI/TIA/EIA-526-14A, Measurement of Optical Power Loss of Installed Multimode Fiber Cable Plant
- ANSI/TIA/EIA-758(A), Customer-Owned Outside Plant Telecommunications Cabling Standard
- ANSI/TIA/EIA-758(A)-1, Addendum No. 1 to ANSI/TIA/EIS-758 Customer-Owned Outside Plant Telecommunications Cabling Standard
- ANSI/ASHRAE Standard 62, Ventilation and Acceptable Indoor Air Quality
- ICC International Building Codes (IBC 2012)
- TIA/EIA TSB-72 Centralized Optical Fiber Cabling Guidelines.
- TIA/EIA TSB-75 Additional Horizontal Cabling Practices for Open Offices.
- Federal Communications Commission's (FCC) Part 15 - FCC Rules Addresses electromagnetic radiation, National Fire Protection Association Life Safety Code (NFPA 101)
- BICSI -- Telecommunications Distribution Methods Manual
- BICSI -- Cabling Installation Manual
- BICSI -- LAN and Internetworking Design Manual
- BICSI – Customer-Owned Outside Plant Design Manual
- BICSI – DD120 Grounding and Protection Fundamentals for Telecommunications Systems
- International Association of Electrical Inspectors – Soares Book On Grounding, NEC-2011

2.2.7. Any questions not answered by referenced technical publications, the job specification (MOP), standard configurations, drawings/records, etc. shall be referred to the OPM.

### 2.3. Environmental Conditions – Temperature and Humidity Guidelines

- 2.3.1. The environment in which telecommunications equipment resides must be maintained to proper conditions in order to minimize service outages and economically optimize the usable life of the equipment. For purposes of this Appendix, all equipment placed in the POI is classified as telecommunications equipment.
- 2.3.2. The standards of this Section 2.3 shall be read as absolute requirements for all POI space that houses Telecommunications Equipment. Under no circumstances during the execution of any MOP shall any telecommunications equipment be energized unless the POI facility in which the equipment resides meets these environmental standards.
- 2.3.3. Temperature, humidity and ventilation requirements are 7x24x365. They must be maintained continuously, even during “off-hours”. Environmental requirements for optimal equipment operation are described in Table 2-1 below:



**Table 2-1: Environmental Requirements for Optimal Operation**

<i>Normal Operating Temperature Limits (can be tighter)</i>	<i>55° to 85° F</i>
<i>Maximum Rate of Temperature Change</i>	<i>2.5° F per 10 minutes</i>
<i>Short Term Temperature Limits</i>	<i>40° to 120° F</i>
<i>Normal Equipment Extended Operability Temperature</i>	<i>32° to 122° F</i>
<i>Operating Relative Humidity</i>	<i>5% to 55%</i>
<i>Short Term Relative Humidity</i>	<i>5% to 90%</i>
<i>Lead-acid Battery Extended Temperature Limits</i>	<i>40° to 95° F</i>
<i>Lead-acid Battery Short-Term Temperature Limits</i>	<i>30° to 122° F</i>

*Table 2-1 Notes:*

1. "Short Term" is defined as not more than 72 consecutive hours and a total of not more than 15 days in 1 year.
  2. Ambient temperature should be measured at a height of 5 feet above the floor, and 15 inches out from the equipment (or in the center of the aisle if it is narrower than 30 inches). These ambient temperatures must be maintained regardless of equipment heat dissipation. Enclosed spaces may need separate temperature control in order to maintain 55-85 °F.
- 2.3.4. In order to determine if the HVAC system is adequate, an approximate heat release of the Telecommunications Equipment is required. The Installer shall be responsible for calculating the approximate heat release for each telecommunications equipment rack/cabinet, including power plant being installed at the POP and for working with the building owner to insure the guidelines of Table 2-1 are met.

2.4. Environmental Conditions – Ventilation Guidelines

- 2.4.1. The standards of this Section 2.4 shall be read as absolute requirements for all POP space that houses Telecommunications Equipment. Under no circumstances during the execution of any MOP shall any telecommunications equipment be energized unless the POP facility in which the equipment resides meets these environmental standards.
- 2.4.2. Ventilation with outside air must be periodically accomplished to relieve buildup of toxic and explosive gasses, and for human safety. For occupied buildings, local codes, the International Building Codes (IBC), and ANSI/ASHRAE Std. 62 specify minimum air change requirements for human occupancy (typically between 2-6 ach). When telecommunications equipment is placed on the portions of the Customer’s Premises that were designed for human occupancy, ventilation of any potential harmful gasses is practically assured. However, when the Customer Premises space was designed as an equipment or mechanical room, care should be taken to ensure that gasses are ventilated. The lead-acid batteries normally used to back up the telecommunications equipment are capable (under high temperature and/or shorted cell conditions) of venting explosive gasses. Even under normal charge conditions these batteries can and will ventilate small amounts of Hydrogen.
- 2.4.3. The Installer shall be responsible for calculating the ach ventilation rate to the surrounding space for each telecommunication equipment rack/cabinet, including power plant, being installed at the POI and for working with the building owner to insure the above referenced guidelines are met. Airflow in the telecommunications cabinets should be from bottom to top, since batteries are traditionally placed at the bottom, and they should receive the coolest air possible.

## 2.5. Environmental Conditions – Air Quality Guidelines

- 2.5.1. The standards of this Section 2.5 shall be read as absolute requirements for all POP space that houses Telecommunications Equipment. Under no circumstances during the execution of any MOP shall any telecommunications equipment be energized unless the POP facility in which the equipment resides meets these environmental standards.
- 2.5.2. Accumulation of airborne contaminants on circuit boards can result in bridging of electrical and electronic circuits leading to circuit faults or intermittent failures. Contamination may be introduced by dust, textile fibers, human debris, soil contributions, products of combustion, etc.
- 2.5.3. Normal air quality operating conditions for telecommunications equipment should be Class 100,000. This means that there should not be more than 100,000 particles of 0.5 microns or greater per cubic foot of air. This can normally be easily obtained by 85% ASHRAE efficiency filtration (pre-filters are probably advisable, depending on the quality of the outdoor air in the city). Short-term (see Note 1 to Table 2-1 for a definition of “short-term”) guidelines are Class 150,000.
- 2.5.4. Proper filtration to achieve the efficiencies mentioned above should be left to the building owner. Local air qualities will determine the amount of filtration needed, and 85% may be excessive.
- 2.5.5. The Installer shall be responsible for insuring that these air quality guidelines are met at POI location. If the customer wishes to determine particle counts in an equipment area, they may refer to Telcordia GR-63-CORE for further information.

## 2.6. Powering Guidelines

- 2.6.1. This Section on Power addresses the general powering philosophy for POI sites. For specific installation guidelines for power, refer to Section 8 of this Appendix.
- 2.6.2. Six (6) hours of DC Plant backup battery reserve (sized at the List 1 or average drains of the served equipment) are required when the AC feeding the rectifiers (reference Section 2.6.9) is not backed up by a permanent standby engine-alternator with automatic transfer switch. Only three (3) hours of backup is required if the rectifiers are backed up by a permanent standby set with automatic transfer switch.
- 2.6.3. It is required that POI installations shall use VRLA (Valve-Regulated Lead-Acid) batteries as approved in the individual POI designs. When VRLA cells are used, the served equipment must be able to tolerate a maximum voltage of -54.8 VDC. Most equipment should easily work at this voltage (the Telcordia NEBS upper voltage limits for equipment design are -56.0 VDC for normal operability, with a short term maximum of -60.0 VDC). If there is equipment that will not function at -54.8 VDC, flooded batteries must be used.

## 2.7. Grounding Guidelines

- 2.7.1. This Section on Grounding addresses general grounding principles. For specific installation guidelines for grounding see Section 10 of this Appendix.
- 2.7.2. For individual and internal ground paths impedance should be kept as low as possible among internal grounding cables to facilitate the flow of electrons back to ground and limit voltage differentials during a lightning strike or power fault to ground. The desirable limit for any internal grounding path back to the building PGP is 0.03 ohms (up to 0.01 ohms on any one branch). The following distances show the 0.01 ohm limit

for the given stranded (preferred) or solid copper cable size: #6 AWG < 20 ft.; #2 AWG < 50 ft.; 1/0 AWG < 80 ft.; 2/0 AWG < 100 ft.; 4/0 AWG < 160 ft.; 350 kcmil < 260 ft.; 500 kcmil < 375 ft.; and 750 kcmil < 575 ft.

- 2.7.3. The initial building ground source is a point from which electrical current will see a low impedance (resistance in the case of DC only) to ground. Per the National Electrical Code, this impedance should not exceed 25  $\Omega$ , a lower impedance is preferred.
- 2.7.4. The POP Facility owner must provide at least one ground source (with a cable sized according to the NEC, at a minimum of #6 AWG — (see Section 2.7.2 for cable sizing requirements based on distance) to an Installer-provided ground bar (within 6 ft. of the POI equipment unless otherwise approved).
- 2.7.5. Grounding cables running to the ground bar shall have a green-colored insulation.
- 2.7.6. The ground source should not be run in ferrous metal conduit. If it is, it shall be end-bonded at both ends of the conduit with a #6 AWG minimum.
- 2.7.7. The Installer shall collect all of its grounds to a single collection point or multiple ground points for larger installations. From each collection point, a cable (appropriately sized depending on the size of the installation) shall be run between the POI ground collection point(s) and the ground bar that represents the extended building ground source. Failing the presence of a ground bar that is an extension of the ground sources, the Installer shall tie the collection bar to the ground source.
- 2.7.8. As mentioned above, all POI grounds shall be connected to a single collection point before connecting that point to the chosen ground source. The collection point shall be a bar, instead of simply a conductor to which all grounds are H-tapped. Depending on the size of the installation and taking into account expansion sufficient to support a fully configured equipment/cabinet, the bar could vary in size and number of holes for termination. The bar may be mounted inside the cabinet, above a relay rack, in a relay rack, hanging from cable rack (and insulated from it), mounted in the space under a raised floor (if that floor is not a plenum, or if the room meets the requirements of Article 645 of the NEC), or mounted on a wall (perhaps inside an electrical cabinet). The bar shall be built for 2-hole lugs. Two-hole irreversible crimp compression lugs are required for all power and grounding connections except for small wall-mount power plants or connections internal to a bay or shelf where the manufacturer's design is for single-hole. When single-hole irreversible crimp compression lugs are used, they must use a star washer to prevent loosening of the connection.
- 2.7.9. Regardless of whether the power plant return busbar is used or a separate bar is provided, the following grounds shall be connected to this "telecommunications equipment ground collection point":
  - Power Plant Battery Return busbar (connected to the telecommunications ground collection bus with a minimum #6 AWG copper wire. If it is a larger installation, this connection may be increased (for example #2 AWG).
  - Equipment Cabinets (Rails, walls, and doors of equipment cabinets shall be electrically bonded to each other, and then a connection shall be made from each cabinet to the ground collection point directly with a #6 AWG, or indirectly to a #2 AWG stringer run from the collection bar).
  - Relay Racks (Equipment relay racks should be connected to the collection point. If there are multiple relay racks and/or lineups, the Installer may run a #2 AWG stringer above each lineup. A splice with a #6 AWG can be made to each relay rack frame from this stringer).
  - Splice Cases (The shields of cables entering the space from the Outside Plant feeding digital equipment should be bonded to a splice case ground point,

which is in turn connected to the collection point with a #6 AWG. If there are metallic cables entering the space that do not feed POI equipment, then their sheath grounds should be tied to the customer's ground bar, as opposed to the POI collection bar). The NEC requires that the protector ground be bonded back to the building grounding electrode, so care must be exercised in equipment placement.

- Appliance Outlet ACEGs (The ACEGs of any appliance outlets in the telecommunications equipment space may be optionally extended to the collection point. As above, this is not necessary if the ACEG or AC Neutral is the ground source).
- Other Metallic Cabinets (any other metallic bays, cabinets, or other metal objects in the POI telecommunications equipment area may be bonded directly to the collection point with #6 AWG, or connected to the collection point through "stringers" as described above. This is especially helpful in reducing ESD problems for cabinets that are used as storage for circuit packs).

## 2.8. Fire Systems and Fire Stopping Guidelines

- 2.8.1. The Equipment Floor Space must meet the local Fire Codes. The walls, floors, and doors should be a minimum of one-hour fire-rated. Fire detectors and alarms shall have remote monitoring capability.
- 2.8.2. Fire-rated openings (as defined by the Customer and/or building/fire inspector) through which cable or conduit passes (whether pre-existing or opened during the installation process) on interior walls or getting from the outside of the building to the inside will be fire-stopped by the Installer.
- 2.8.3. When fire-stopping new cable penetrations, an attempt should be made to utilize the Premises owner's preferred materials, provided they meet or exceed Project standards.
- 2.8.4. Where existing cable penetrations are disturbed, they must be re-sealed with like materials. Mixing of fire-stop materials is prohibited.

## 3. Installation Guidelines

### 3.1. Site Construction and Equipment Staging Guidelines

- 3.1.1. The amount of space and its location required for temporary storage of build out materials, tools and telecommunications equipment shall be a matter of agreement between the Installer and the OPM prior to the start of a job. Every attempt shall be made to locate this area outside the room or compartments containing active telecommunications equipment. In those cases where this cannot be accomplished, the area should be set as far away as possible from the active equipment locations.
- 3.1.2. All equipment and materials shall be unpacked and cleaned outside of the facility or in the facility's authorized unpacking area. Equipment and materials shall be free of contaminants prior to being brought into the POI equipment area.
- 3.1.3. The cutting, filing, drilling, and milling or painting of auxiliary framing, cable rack, etc. should be done outside of the POI equipment area whenever possible. When cutting, filing, drilling of equipment that cannot be removed from a facility, proper protection, and the use of a High Efficiency Particulate Arrestor (HEPA) vacuum, capable of filtering particles larger than 0.3 microns in size, and equipped with a static dissipative hose shall be required.

- 3.1.4. All drilling of the equipment building envelope, consisting of floors, walls, ceiling, or any wall or separation therein, should be accomplished in a safe and environmentally sound manner, which captures and contains any debris using proper protective materials and HEPA vacuum, capable of filtering particles larger than 0.3 microns in size, and equipped with a static dissipative hose.
- 3.1.5. Portable electrical tools shall be equipment grounded or of the double insulated type.
- 3.1.6. All extension cords being used shall have a grounding conductor. Multiple plug adapters shall be prohibited. Use of extension cords beyond the installation interval is prohibited in a POP environment.
- 3.1.7. Ground-fault circuit interrupters shall be installed when temporary 15 or 20 ampere, 120 volt AC circuits are required to perform construction, demolition, modifications, alterations or excavations. Extension cords are considered to be temporary wiring and must be equipped with a ground lead (e.g., 3-pronged plug).
- 3.1.8. Suitable disconnecting switches or plug connectors at the junction with permanent wiring shall protect all temporary circuits.
- 3.1.9. Electrical installations in hazardous dust or vapor areas shall conform to requirements outlined in the National Electrical Code (NEC) for hazardous locations.
- 3.1.10. Exposed wiring and cords with frayed or deteriorated insulation shall not be used. Flexible cords and cables shall be free of splices or taps. Clamps or other securing means provided on flexible cords or cables at plugs, receptacles, tools, equipment, etc. shall be securely held in place. All cord, cable and raceway connections shall be intact and secure.
- 3.1.11. All disconnecting switches and circuit breakers shall be labeled to indicate their use or equipment served. Disconnecting means "shall always be opened before fuses are replaced.
- 3.1.12. Interior wiring systems shall include provisions for grounding metal parts of electrical raceways, equipment and enclosures. Electrical raceways and enclosures shall be securely fastened in place.
- 3.1.13. All energized parts of electrical circuits and equipment shall be guarded against accidental contact by approved cabinets or enclosures.
- 3.1.14. Sufficient access and working space shall be provided and maintained about all electrical equipment to permit ready and safe operations and maintenance. NEC Article 110.26 provides requirements for working clearances in front of, to the sides of, above, and below AC equipment.
- 3.1.15. Unused openings (including conduit knockouts) in electrical enclosures and fittings shall be closed with appropriate covers, plugs or plates. Electrical enclosures such as switches, receptacles, and junction boxes, shall be provided with tight fitting covers or plates.
- 3.1.16. General cleaning of the POP equipment facility or storage area in which work is being done is to be performed by the Installer during the entire installation or removal process. Care shall be taken to generate a minimal amount of airborne dust. The Installer should use only a HEPA vacuum, capable of filtering particles larger than 0.3 microns in size, and equipped with a static dissipative hose to capture dust and chips from the drilling of floors, walls, ceiling, ironwork, and equipment during the uncrating process, and while cleaning cable racks and equipment.

### 3.2. Electrostatic Discharge (ESD) Guidelines

- 3.2.1. A wrist strap connected to an appropriate ground terminal shall be worn by the Installer when removing, inserting, or handling devices and components not in static dissipative packaging. The wrist strap shall be snug fitting and make contact with the skin.
- 3.2.2. The Installer should test each of their wrist straps daily (on days when they are going to use them) with either a pass/fail wrist strap test set or by using a Volt- Ohm meter. The reading shall be  $1M\Omega \pm 15\%$ .
- 3.2.3. The Installer shall maintain a static safe environment for the handling of circuit packs and other electronic equipment. All containers or packing materials used shall be marked with ESD warning labels.
- 3.2.4. The Installer shall minimize the handling of circuit packs. Devices and components shall be stored in their static dissipative packaging prior to insertion in the equipment. Package and transport all circuit packs, including those presumed defective, in an approved protective static dissipative container. When removing a circuit pack from service, the pack shall be immediately placed in an anti- static, protective container. The correct size container shall be used to adequately contain and physically protect the individual circuit pack.
- 3.2.5. Circuit packs shall be handled by their front face plates. If additional support is required, use the outermost top and bottom edge, being careful not to touch any components or conductive paths.
- 3.2.6. Keep synthetic fibers, plastics, foams, etc., which are not anti-static, out of the environment where circuit packs are being handled.

### 3.3. Fire Protection Guidelines

- 3.3.1. Nothing shall be placed on top of a unit of equipment that interferes with the airflow necessary for the cooling of that equipment.
- 3.3.2. All doors in an equipment room should be kept closed at all times. Fire doors and internal security doors shall not be blocked open or have lock assemblies impeded or disabled.

### 3.4. Assembly and Iron Work Guidelines

- 3.4.1. The location of auxiliary framing, cable racks, frames, relay racks, bays, cabinets, and other equipment shall conform to the particular plans, drawings/records, and specifications for each installation in accordance with the previously approved POI civil design.
- 3.4.2. Overhead clearance in all aisles and equipment areas must be maintained at a minimum of 7 feet, unless otherwise approved by MTC. This includes auxiliary framing, cable rack, cableway systems, grounding feeders, vent ducts, conduit, lighting, etc. Environments with 9 or 11.5-foot equipment shall maintain clearance's equivalent with the 9 or 11.5-foot heights.
- 3.4.3. Where applicable Unistrut may be installed to support telecommunication equipment environments.
- 3.4.4. Auxiliary framing used exclusively for the support of cable rack shall be consistent with other existing levels of framing where possible to be consistent with current standard arrangements.
- 3.4.5. Where one additional row of frames is to be ultimately installed, the auxiliary framing shall be engineered to allow for the ultimate installation build-out of cable rack.

- 3.4.6. All assemblies and ironwork referred to in this section should be installed to meet Seismic zone requirements for the area in which they are installed.

### 3.5. Bolts, Threads, Screws, and Threaded Rod Guidelines

- 3.5.1. All bolts, nuts and screws used to secure any part or unit shall be plated to prevent corrosion (an exception are solid copper and stainless hardware), tight, plumb; free of damage, and meet specific / manufacturer's torque requirements where required.
- 3.5.2. All threads of a nut must be used. Bolts/screws may protrude beyond the nut, but not to the extent that they would create a safety or service hazard. Maximum allowable protrusion, where exposure may create a safety or service hazard, shall not exceed the diameter of the threaded unit.
- 3.5.3. Both ends of bolts, screws or threaded rods shall be free of sharp edges.
- 3.5.4. Threaded rod splices may be used only under the following conditions:
- The splice has jam nuts installed top and bottom.
  - The splice has an inspection hole in the center of the splice to permit visual confirmation that the two rod sections are fully inserted and meet in the center of the splice.
  - Where no practical alternative exists for the installation of non-spliced thread rod of the correct length.
  - Only one splice may be used.
- 3.5.5. The tips of all cotter pins shall be bent back and rest against the rod to prevent injury from projecting ends.

### 3.6. Cable Racking Guidelines

- 3.6.1. All cable racks shall be of the proper size and type, and located, leveled and aligned per the individual approved POP design.
- 3.6.1.1. All sections of cable rack shall have both stringers supported at a minimum of one point, regardless of length. An exemption is made for short transition racks or vertical/horizontal bends. Vertical cable rack shall be supported with a minimum of two supports. The ends of both cable rack stringers shall be bolted to the auxiliary framing support and a minimum of one bolt is required at intermediate auxiliary framing supports on alternate sides of the rack. Additional intermediate bolts may be required depending on actual support requirements.
- 3.6.1.2. Cable rack runs consisting of one piece of rack require a minimum of two points of support on each cable rack stringer (a minimum of four points of contact/supports per cable rack).
- 3.6.1.3. Maximum distance between supports shall not exceed six feet (standard spacing is 5 feet). Distance between last supports and cable rack ends shall not exceed three feet. Sections of cable rack four feet or less in length may be supported by two corner clips at each end. Transition cable racks do not need to be supported unless they are longer than 6 feet. Supporting shall be accomplished by drilling the sides of the cable rack, and installing an angled drop rod bracket on each side. Cable rack stringer splices do not constitute a support.
- 3.6.2. Cross-aisle sections of cable rack five feet or less in length may be supported by two corner brackets.

- 3.6.3. Open and protruding ends of ladder type cable rack shall be finished with closing details or protective rubber caps. All splices, junction details, brackets, and hangers shall be securely installed according to the individual POP design.
- 3.6.4. New cable rack shall be of the solid bar stringer type. The installation of new tubular or hollow stringer type cable rack is prohibited. However, in POP facilities where there is existing tubular or hollow stringer type cable racking, the same racking material may be used provided there is no reasonable way of incorporating the preferred solid bar stringer type and provided the allowable support loads for the existing cable racking will not be violated. At locations where there is existing channel stringer type cable racking, solid stringer cable rack should be used to as an extension to complete the POP installation.
- 3.6.5. Cable rack shall be placed above the front aisle whenever possible. Where this is not possible, consideration should be given to heat dissipation, size of the cable rack (loading), and installer access when placing cable rack in the rear aisle.
- 3.6.6. A minimum vertical clearance of 12 inches shall be maintained above cable racks.
- 3.6.7. Power cable rack located within the power room area for battery stands and power board equipment will be set at a minimum of 8 feet from the floor to the top of the cable rack stringer whenever practical, or as designed according to the previously approved individual POI civil design.

**Note:** Ground windows, due to their arrangement, may constitute a lower minimum cable rack height or where lower ceiling conditions dictate. In these instances, the power cable rack shall be located no lower than 6 inches above top of cabinet. This lower power cable rack height may also be used where low ceiling heights require power cable racks to be placed at this lower level.

- 3.6.8. When horizontal switchboard or fiber cable rack has a vertical change in elevation of more than 9 inches, a connecting cable rack (waterfall) shall be installed between the horizontal levels of cable racks. When horizontal power cable rack has a vertical change in elevation of more than 12 inches, a connecting cable rack (waterfall) shall be installed between the horizontal levels of cable rack. The connecting cable rack shall be installed typically at an angle (as close as possible to either 45° or 90° as applicable).
- 3.6.9. The height of cable rack is measured from the finished floor to the top of the cable rack stringer.
- 3.6.10. Standard lengths of cable rack and / or auxiliary channel should be installed wherever possible.
- 3.6.11. Cable rack should be placed above the center of the row of cabinets unless wall mounting space becomes an issue in which case the cable rack should be positioned closer to the rear of the cabinets where the cable knock outs are located.
- 3.6.12. Cable racks positioned vertically for the purpose of adjoining parallel horizontal cable racks at different elevations (offsets greater than 9 inches for switchboard or fiber or 12 inches for power) shall be installed at a 45° or 90° angle, as applicable, using fixed-degree edge clamps.
- 3.6.13. Cable rack brackets shall be placed at intervals not to exceed 18 inches. Cable rack stand offs shall be staggered (on alternating sides of every other cable rack cross-strap). At crossing points and where cables break off the racks, it may be necessary to locate additional brackets to add protection for the cables when cables are unsupported for more than 12 inches.



- 3.6.14. Where only one cable tray is being placed in a POI, cable stand offs shall be used to keep data cable separated from power cables. AC and DC power cables shall be kept separated on cable stand offs.

### 3.7. Fiber Optic Protective / Distribution System Guidelines

- 3.7.1. Systems installed in equipment locations shall be assembled and aligned per drawings/records, specifications, Technical Publications, Standard Configurations, and technical documents.
- 3.7.2. Fiber optic cable troughs shall be used to support OFN fiber cable patch cords/jumpers or OFNR (1-to-8 fibers/cable) and troughs should be sized according to greatest possible number of customers plus an additional 40%.
- 3.7.3. All covers and devices used to maintain fiber cable/jumpers within their horizontal and vertical protective duct systems shall be in place and secure.
- 3.7.4. The use of "split flex" tubing within vertical or horizontal fiber trough or raceway systems is restricted.
- 3.7.5. Fiber optic cables and jumpers shall be run on dedicated racks or in existing dedicated cableways.
- 3.7.6. Maximum length of fiber slack storage available for placement in approved fiber management systems is defined in the manufacturer's documentation for fiber slack storage devices. Fiber slack storage in cable racks or fiber management system systems is prohibited.
- 3.7.7. A dedicated cable slot/hole/sleeve shall be used for fiber cable entering the equipment facility from the cable entrance facility with provisions for approved fire/smoke and gas stopping.
- 3.7.8. Using cable sleeves associated within distributing frames for running fiber cable is prohibited. Placing any type of fiber management systems and OFN rated fiber cables through a floor or wall cable penetration is prohibited.
- 3.7.9. Horizontal sections of solid fiber management system shall be supported per manufacturer requirements as follows (Also Reference Figures 3-1 and 3-2 below):
- 2" X 2" solid = 2'- 6" on center standard, 3' maximum.
  - 4" X 4" and 4" X 6" = 5 feet on center.

**Figure 3-1:**  
**Typical Horizontal Fiber Management System**



**Figure 3-2:**  
**Typical Horizontal Fiber Management System with Bend**



- 3.7.10. Vertical 2"X 2" multi-slotted fiber management arrangements shall be provided for every relay rack or cabinet requiring patch cord termination. Fiber cables transitioning from a horizontal fiber management system must be loosely bundled and secured as close to the top of the vertical 2"X2" multi-slotted fiber management system as possible using the holes on the back of the duct. Sharing a single duct between two bays is prohibited except as described in Section 3.7.11.
- 3.7.11. Sharing a single fiber management system downspout between two bays in a POI lineup is allowed where a trumpet flare fitting is used on the downspout and the horizontal duct can be located so the vertical fiber cable can drop almost directly into the 2"X2" multi-slotted vertical duct.

### 3.8. Equipment Frames, Bays, Cabinets, and Stands

- 3.8.1. Locate all frames, bays and piece parts per job specification and drawing/record. All frame parts shall be free of defects, secure, and aligned.
- 3.8.2. All frames, and bays, shall have a minimum of two top supports and a minimum of two bottom floor supports. Specific manufacturer designs may require additional top or floor supports (e.g., cabinets and BDFB's require four top supports).
- 3.8.3. Frame guardrails, end guards, and spacers shall match and be in alignment, as indicated by the floor plan (front of frame bases shall be flush). Transition plates or guard rail adapters shall be installed where this cannot be accomplished.
- 3.8.4. Cabinets on casters or rollers shall have the rolling system disabled or removed and be anchored to the floor.
- 3.8.5. The vertical alignment of all frameworks should be plumb within the allowable deviations shown in Table 3-1 below:

**Table 3-1: Framework Alignment and Clearances**

VERTICAL ALIGNMENT				
(Maximum Allowable Deviation From Plumb)				
Height		Maximum Deviation		
4' 6" or Less		1/16"		
Over 4'6" and Less than 7'		1/8"		
7' to 9' inclusive		3/16"		
Over 9'		1/4"		
HORIZONTAL ALIGNMENT				
Should be Level				
COMPONENT PERPENDICULAR TO WALL OR COLUMN				
Equipment Type	Standard Distance From Wall (Aisle)	Minimum Distance From Wall (Aisle)	Standard Distance From Column	Minimum Distance From Column
Equipment Frames or Cabinets	4"	3"	6"	6"
Auxiliary Framing	6"	6"	6"	6"
Cable Racking	6"	6"	6"	6"
AISLE SPACING				
Equipment Type	Standard Front Aisle	Minimum Front Aisle	Standard Rear Aisle	Minimum Rear Aisle
Toll Equipment (up to 1200 Watts)	3'	2' 6"	2' 6"	2'
DC Power (BDFB, PBD)	3'	2' 6"	2' 6"	2'
Front Access Eqpt. (e.g. CEV's, CPE)	3'	2' 6"	6"	
Battery Stand	3' 6"	3"	3' 6"	3'
AC Powered Eqpt. (Rated ≥240VAC)	3'		3' (If Rear Access Is Required)	
AC Powered Eqpt. (Rated ≤480VAC)	3' 6"		3' 6" (If Rear Access Is Required)	
Main Aisles and Egress Routes	Any egress aisle, to the front, rear, or side of a bay, shall be a minimum of 4 feet wide			

- 3.8.6. Table 3-1 Notes:
- This distance to a column is for the end of a bay to the column. Standard and minimum front or rear aisle spacing will apply to distances from the front or rear of a bay to a column
  - **Toll Equipment** is defined as traditional fan-led telecommunications equipment with a total heat release of less than 1200 Watts per bay or cabinet.
  - **Data Equipment** is defined as technologically advanced and concentrated telecommunications equipment with a total heat release greater than 1,200 Watts.
  - **Main Aisle** in a POI environment provides space for placement of feeder cable racks, conduit, equipment lineup designation numbering and identification, and breaks at the ends of the 50-foot equipment lineups. The main aisle may also be considered the main egress, see below.

- **Egress** is defined by OSHA as "Means of egress." A means of egress is a continuous and unobstructed way of exit travel from any point in a building or structure to a public way. For our purposes a public way is defined as an exit that leads out of the building.
  - Equipment frame aisles will be measured from the outer most edge of the frame guard rail or guard rail extension to the outer most edge of the opposite frame guard rail or guard rail extension.
  - Cabinets with doors that extend beyond the base of the cabinet shall be measured from the outer most edge of the portion of the cabinet which protrudes the farthest.
  - Main aisles are measured from the outer most point of the end guard attached to the first frame in one lineup to the outer most point of the end guard attached to the first frame in the lineup directly across the new main aisle. Aisle shall be considered clear and unobstructed space.
  - A maximum difference of 3 inches in depth is allowable for framework or cabinets within a single lineup. For the purpose of aligning the frame flanges, a protrusion of 1 inch into the front aisle is allowable. If the frame protrudes into the front aisle 1 inch, the rear guard rail depth can be increased a maximum of 2". Frame base footprints can be adjusted by adding approved guard rail extensions or by replacing the front or rear guard rails to bring the base footprint depth within 3".
- 3.8.7. Frame bases, end guards, and spacers shall match and be in alignment. Transition plates or guards shall be installed where this cannot be accomplished.
- 3.8.8. The uprights of all frames or cabinets (7 feet high or taller) where the flanges align will be junctioned together. Equipment frames 7 feet high require a minimum of three junction plates. Taller equipment frames require a minimum of four junction plates.
- 3.8.9. All battery stands shall be floor-secured to meet manufacturers' recommendations.
- 3.8.10. The distance between the TOP of a pipe stand and the BOTTOM of the supported ironwork shall not exceed 2 inches.

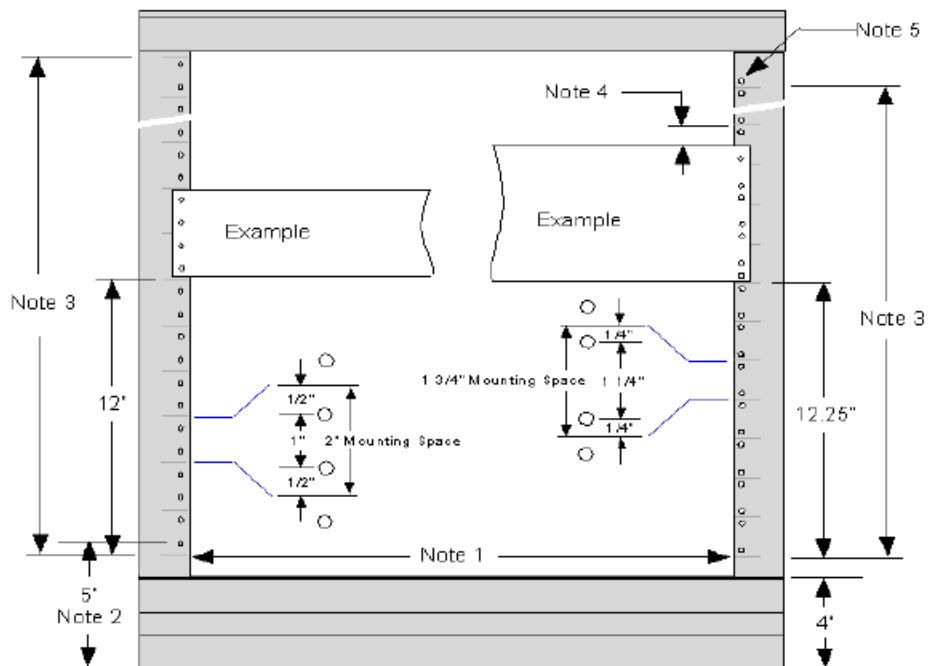
### 3.9. Framework and Iron Work Components

- 3.9.1. All piece parts (i.e., ironwork, framework, threaded rod, miscellaneous details, etc.) shall be installed per equipment drawings/records and shall be secure, aligned, plumb, and free from defects, sharp burrs, points, etc.
- 3.9.2. All splices on cable racks, auxiliary framing bars or junction bars shall be butted together or butted against junction hardware. Gaps shall not exceed 1/8".
- 3.9.3. All surfaces of equipment and ironwork parts shall be free of rust, dirt and contaminants. If rust is apparent on equipment or parts, they shall be cleaned and painted.
- 3.9.4. All cut ends of cable rack auxiliary framing, threaded rods, and other unprotected metal parts shall be plated or painted.
- 3.9.5. End guards shall be provided for end of equipment lineups, and end shields provided when frame duct / uprights (wiring and cables) are exposed within an equipment lineup, according to the individual POP Design. End guards are required to close off frames where spacers are needed.
- 3.9.6. Approved stanchions shall be secured with 2 floor anchors of the correct size or 4 floor anchors of the correct size in accordance with the individual approved POI design.

3.10. Guidelines for Mounting of Shelving / Equipment

- 3.10.1. All units of equipment, including cabling and brackets, shall be installed, aligned and secured in accordance with job specifications and drawings.
- 3.10.2. When mounting positions are identified in inches or in fractions of inches, these measurements are from the lowest mounting position to the uppermost mounting position. The actual measurement to the physical bottom edge of the shelf may vary depending on manufacturer design but the shelf should not infringe on an adjacent mounting space. (Refer to Figure 3-3 below).

Figure 3-3: Mounting Hole Reference



3.10.3. Figure 3-3 Notes:

1. The bottom of the first mounting space in a framework is the zero (0) reference point.
  2. The location of the first mounting hole will vary depending on the type of framework (Network, Unequal Flange, etc.) and the mounting space configuration (1 3/4", 2").
  3. Refer to Table 3-2 for numbers of mounting spaces in varying frameworks.
  4. In some cases this portion of a mounting space may need to be designated as "space not available" (SNA). The next added shelf may need to start at the next full mounting space.
  5. Besides the tapped holes for mounting equipment some frameworks may be equipped with additional holes above or below the actual mounting spaces. The mounting of equipment in these locations is prohibited.
- 3.10.4. All Installer mounted units shall be secured with a minimum of four screws (one screw each in the upper and lower most available mounting holes on each side of the unit). Units exceeding 8 inches in height require 1 additional mounting screw on both sides

for each additional 8 inch interval. Additional screws may be required for heavier units or as required by manufacturers' specifications.

3.10.5. Mounting space adapters shall be used where hole spacing is incorrect for the equipment being mounted in the frame, bay, or cabinet. The frame, bay or cabinet shall not be drilled to accommodate equipment mounting.

3.10.6. All equipment shall be mounted as designed according to the previously approved individual POI civil design.

3.10.7. Where equipment is wall mounted, it generally should not be mounted above 7' from finish floor.

### 3.11. Floor Anchors and Installation Guidelines

3.11.1. Floor Anchor Installation Instructions are provided by the manufacturer, and shall be followed by the Installer.

3.11.2. The requirements for floor anchors apply to equipment frames, stanchions, cabinets, DF frames, etc. Exceptions are allowed for anchoring ironwork assemblies, such as cable rack.

3.11.3. An anchor bolt assembly with red slip ring (example Hilti® item #230712) is approved for use on all floor anchoring applications (with the exception of battery stands, see section 3.12.5). The anchors are available in kit form containing two anchors and two 2" X 2" hold-down plates. The anchor has a 2-1/2 inch (~70 mm) insertion depth and a 60mm embedment depth. The head of the torque-indicating anchor will break off at 60 foot pounds when installed correctly.

3.11.4. Frames and cabinet must be anchored prior to cable termination, top supporting, or junction to adjacent bays. If floor depth problems are encountered, the Installer shall contact the Installation Supervisor who will coordinate a resolution. Floor anchor holes shall not exceed the 70mm pilot hole depth of the anchor bolt assembly.

3.11.5. An anchor bolt assembly is required (example Hilti® item # 97413007) for use on all battery stands placed in any telecommunications power area.

### 3.12. Floor Anchors and Installation Guidelines

3.12.1. Floor Anchor Installation Instructions are provided by the manufacturer, and shall be followed by the Installer.

3.12.2. The requirements for floor anchors apply to equipment frames, stanchions, cabinets, DF frames, etc. Exceptions are allowed for anchoring ironwork assemblies, such as cable rack.

3.12.3. An anchor bolt assembly with red slip ring (example Hilti® item #230712) is approved for use on all floor anchoring applications (with the exception of battery stands, see section 3.12.5). The anchors are available in kit form containing two anchors and two 2" X 2" hold-down plates. The anchor has a 2-1/2 inch (~70 mm) insertion depth and a 60mm embedment depth. The head of the torque-indicating anchor will break off at 60 foot pounds when installed correctly.

3.12.4. Frames and cabinet must be anchored prior to cable termination, top supporting, or junction to adjacent bays. If floor depth problems are encountered, the Installer shall contact the Installation Supervisor who will coordinate a resolution. Floor anchor holes shall not exceed the 70mm pilot hole depth of the anchor bolt assembly.

3.12.5. An anchor bolt assembly is required (example Hilti® item # 97413007) for use on all battery stands placed in any telecommunications power area.

3.13. Equipment and Cabling Labeling & Naming Guidelines

- 3.13.1. All designations should be accurate, permanent, legible, visible, aligned, secure, the proper color, at the prescribed location, complete, and conform to standard equipment designation patterns. Refer to **Appendix H: Network Equipment Labeling and Naming Standards** for examples of labels that could be used in a POP.
- 3.13.2. The use of labeling machines with black lettering on white background is required.
- 3.13.3. Labels should be located on the part of the frame, bay, or cabinet that is not normally removable by maintenance personnel and which shall remain fully visible.
- 3.13.4. Stamping on painted or plated surfaces must be approved by OPM.
- 3.13.5. Designate connectors on connectorized cables as identified in the MOP or drawing/record. All connectorized cables that could be removed and improperly re-plugged shall be identified with connector or jack number.
- 3.13.6. Designate all frames, bays, shelves and cabinets, with frame type (BDFB, RR, etc.) and number on the front and rear. The recommended locations are: first choice — frame base; second choice — mid-frame to eye level left frame upright, or as the existing office convention dictates. The designations shall be readily visible.
- 3.13.7. Designate each shelf, unit, or position on the front and rear or as instructed in the detailed MOP and drawings/records. The procedure for numbering shelves within a bay, relay rack or equipment frame shall be consistent for all network elements utilized across all POI's. Refer to **Appendix G: Cable and Wire Lacing Techniques** for label formatting examples.
- 3.13.8. Shelves, units, and positions in the same frame shall be numbered as follows: lowest to highest, bottom to top, left to right; as viewed from the front.
- 3.13.9. Shelf, panel, bank, and fuse panel numbers shall consist of two digits, starting with 01, and be unique within a given frame; i.e., there shall be only one shelf, panel, bank, or fuse panel 01, 02, 05, 19, etc. Typical single frame designation formats could be as follows: SH-01, BK-02, PN-03, FP-04, etc. Units should have an electrical connection (power, fiber, frame, timing, alarm, etc.) in order to be designated. Frame filler plates, heat deflectors, and cableways should not be given a shelf number.
- 3.13.10. Designate all AC circuits connected at utility outlets, inverters, rectifiers, and power strips. These circuits shall be designated at the source (panel) and at the equipment.
- 3.13.11. Higher voltage receptacles (those greater than nominal single-phase 120 VAC) shall have the receptacle cover plate marked with the appropriate voltage (e.g., 208V AC, 240VAC, 277V AC). Stamp or label with three sixteenths of an inch or equivalent font characters in vermilion (red) ink.
- 3.13.12. Electrostatic Discharge (ESD) All framework connectors for ESD wrist straps shall be designated with the term "ESD" or shall be designated with the universal symbol for ESD.
- 3.13.13. All forms of DC distribution shall be clearly designated both front and rear as to frame, panel, row, plate, fuse / breaker position, voltage, and load so as to coincide with equipment and assignment drawings/records. BDFB fuse / breaker positions shall be numbered from the top down, with consecutive numbering for each load.
- 3.13.14. Fuse panels assignment designations shall show a minimum of Frame / Bay / Cabinet, shelf / plate number and amperage for all assignments. All fuse panels assignments shall be designated using an approved labeling system (i.e. Designation card or label, fuse assignment book, direct labeling).

## 4. Cabling: Forming, Running, Securing and Repairing Guidelines

### 4.1. General Requirements

- 4.1.1. The requirement for cable routing and segregation shall be per job specification and records/drawings, except where manufacturers' requirements, critical routing, and/or critical lead lengths shall take precedence.
- 4.1.2. Route cables to avoid pileups and blocking of cable runs. All cables shall be run within the confines of the cable rack stringers. Do not run cables on existing cable racks where cable pileup exceeds the top of existing cable horns.
- 4.1.3. Cables shall be run directly, from point to point, with only a maintenance loop of slack (not to exceed 4 feet) stored on the cable rack. All "maintenance loop" cabling must remain within the confines of the cable rack or designated cable support system. Routing of cables between relay racks and frames without using the overhead cable support systems is prohibited.
- 4.1.4. Placement of vertical splices, adapters on or in the relay rack uprights and cable ways and or horizontal/vertical cable support systems is prohibited.
- 4.1.5. Supporting or securing of any cable to AC conduit is prohibited.
- 4.1.6. Cable spanning horizontal planes shall not exceed 9 inches without additional support. Vertical cable rack offsets of greater than 9 inches in parallel planes shall be made using fixed degree edge clamps. Where it is not practical to use fixed degree edge clamps for vertical offsets, adjustable clamps may be utilized. Interim support points (auxiliary framing, conduit, etc.) must be installed so as not to interfere with future cross aisle cable racks or cable access to bays, cabinets, BDFB return bars, etc.
- 4.1.7. Remove all cable running tags and binder grouping material after the completion of testing.
- 4.1.8. Cable and cable management systems shall be at a distance sufficient to maintain a maximum cable enclosure temperature of 115° F. At a minimum, the distance shall be no less than six inches clearance from steam pipes, or other environmental hazards.
- 4.1.9. Where cables transition off a cable rack, they shall be routed over the side stringers or off the end of a cable rack that will not be extended at some future date. A typical installation is shown in Figure 4-1 below:

**Figure 4-1: Typical Cable Transition**





- 4.1.10. Cables shall not be routed through the cable rack. All cables dropping into a frame from a horizontal cable rack or duct system must be routed to align as directly above the frame upright or vertical duct system as possible. At no time will cable of any type make a horizontal transition greater than nine inches across the top of the bay to access the opposite bay upright or vertical duct arrangement. Overhead horizontal cable rack or duct systems must be extended beyond the location below where the cable will enter the bay upright or vertical duct.
- 4.1.11. All cable connections within a bay shall be supported within 24 inches of a point of termination.
- 4.1.12. Cables larger than No. 14 AWG must not be routed through a frame's uprights.
- 4.1.13. All cables should have a label with CLLI code printed on both ends, to/from locations using a sticky rolled label ( example - communications cables) or flag tag label (example – power cables). Examples of cable labels are shown in Figures 4-2 and 4-3 below:

**Figure 4-2:  
Typical Flag Label**



**Figure 4-3:  
Typical Rolled Label**



#### 4.2. Cable Bending and Forming Guidelines

- 4.2.1. Sharp bends in cables shall be avoided to prevent damage to insulation and conductors. Table 4-1 below provides the minimum bending radii for cable and wire:

**Table 4-1: Minimum Bending Radius for Cable and Wire**

Cable Type	Bending Radius
Power Cable	9 Times Cable Diameter
Armored Cable (BX), Flexible Steel	5 Times Cable Diameter
Grounding Conductor	1 Foot Minimum (12 inches)
Fiber Optic – Single Fiber	1-1/2 inches
Fiber Optic – Dual Fiber	2-3/4 inches
Fiber Optic – Quad Fiber	3-5/16 inches
Fiber Optic – 12 Count or higher	If manufacture's requirements are not specified, diameter times 10.
Cable and Wire not specified above	10 Times Cable Diameter

#### 4.3. Cable Protection and Storage Guidelines

- 4.3.1. Protect all cables and wires against damage at all locations where they come in contact with sharp edges or threaded rod, using sheet fiber paper, plastic edge

- guard, and/or protective tubing as appropriate. Refer to Figure 4-1: Typical Cable Transition, for example.
- 4.3.2. Wherever fiber cables may come in contact with any sharp or metal edge, the cable shall be protected with sheet fiber paper or equivalent. Fiber jumpers and cables shall be protected from lacing twine by wrapping the fiber in one layer of sheet fiber paper.
  - 4.3.3. All cables stored for future use shall be identified at the point of termination with both far and near end location information. All cables shall be stored in a manner that allows for future access.
  - 4.3.4. Cables run (extended), but not yet connected, shall be coiled, banded, and stored in a manner that shall not damage equipment or cause a safety hazard. Under no circumstances shall unconnected cables be stored in the cable rack system, in frame uprights, or vertical duct systems. Unconnected cables in cable support systems must be removed.
  - 4.3.5. Plastic electrical tape or heat shrinkable tubing shall be used to wrap/protect the butt location of ABAM and shielded cables.
  - 4.3.6. All cables shall have their exposed ends covered (taped) during the running process to protect existing equipment. The tape shall be left on until the cables are terminated.
  - 4.3.7. All types of cable rack that have threaded rod(s) in contact with the cable rack, shall have the threaded rod(s) protected with protective tubing.
  - 4.3.8. Provide protection using fiber sheathing on inverted ladder-type cable rack in a horizontal or vertical plane where the wire and cable are in contact with the flange side of the cross straps.
  - 4.3.9. Power wires fastened to the underside of channel type cable rack straps shall be protected.
  - 4.3.10. Cables on distributing frames that are butted at the traverse arm require fiber protection or fanning rings.
  - 4.3.11. All soft rubber insulated cables require protection when secured with 9-cord, or equivalent. Cable insulation that will not cold flow is exempt from this requirement. Cold flow is a condition where insulation thins or flows away from an impingement point.
  - 4.3.12. All exposed ends of power or ground cables shall be protected with rubber insulating tape and plastic electrical tape or heat shrinkable end caps. This requirement applies specifically to common feeders serving multiple bays or cables that have been dead ended.

#### 4.4. Cable & Wiring Securing and Supporting Guidelines

- 4.4.1. All cables and wires are to be secured in a manner that affords access to the equipment.
- 4.4.2. All cables shall be tied with 9 cord, or equivalent, at cable rack break-off points, banded or tied between the cable rack and first support (where this distance exceeds eighteen inches), and tied at the first available support (cable support bracket) on a frame, bay, vertical fiber management system or cabinet. Where no cable support bracket exists, the Installer shall secure cabling through rear relay rack upright mounting holes or rear vertical fiber management system mounting holes to meet the eighteen-inch requirement provided that cable bending radius tolerances are maintained (reference Section 4.2). At the point of break-off the cable rack stringer

- (side of the cable rack) cables shall be bundled together and protected with sheet fiber paper or equivalent. When cable rack pileup prevents the installer from securing cables at the cable rack break-off, they shall be secured to the existing cables.
- 4.4.3. Horizontal runs are to be sewn every sixth strap and when necessary to keep cable in the cable rack or from sagging through the cable rack. Vertical runs (and waterfall rack) are sewn on every alternate strap. No more than two square inches of cable shall be secured under a single stitch. The band between cable rack break-off and first frame support is exempt from the two square inch requirement. (See Table 4-3: Cable Securing requirements).
- 4.4.4. To the extent possible and prudent, cables shall be sewn in complete layers the approximate width of the cable rack before starting additional layers.
- 4.4.5. Installer may leave securing cord provided that an ending stitch is made and the cord is properly stored (secured back so that it doesn't provide a safety hazard for equipment or personnel) for future use. No excess securing cord slack shall be allowed in equipment frames or on cable racks.
- 4.4.6. Care shall be taken, when sewing or banding, not to indent or collapse coaxial cables. Fiber sheet or protective-tubing protection may be required.
- 4.4.7. Where cables extend from a ceiling supported racking system to equipment frames that are floor supported only, or not physically connected to the feeder rack, an additional 9 inch slack loop shall be provided. Where no vertical cable support bracket exists, the Installer may secure cabling using the rear relay rack upright mounting holes to meet the eighteen-inch requirement provided that cable bending radius and strain relief tolerances are maintained. At the point of break-off the cable rack stringer (side of the cable rack) shall be protected with cable rack sheet fiber paper or equivalent.
- 4.4.8. All non-fiber cables and wires shall be secured at intervals not to exceed three sheath feet in protected ducts or eighteen inches in open ducts and at all turns or junctions within the frame, bay, or cabinet.
- 4.4.9. Cable ties used for banding of fiber protection, PVC protection etc. shall be of an adequate size, type, strength, etc. for the particular application. Tightening cable ties to the point of damaging the cable is prohibited.
- 4.4.10. Cable ties shall be trimmed at the locking head with a flush cutting device that provides automatic tensioning.
- 4.4.11. Under no circumstances shall cable ties have sharp or jagged cut ends protruding from the locking head. A cable tie is considered to have sharp or jagged ends when it is sharp to the touch.
- 4.4.12. The locking head of reusable cable ties shall be positioned so as not to interfere with the installation or removal of apparatus or equipment.
- 4.4.13. When superimposing additional cable or wire to forms, existing cable ties shall be removed where the heads of tie wraps interfere with additional cable or wires.
- 4.4.14. Where cable or wire forms are secured to cable securing brackets, the locking head of the cable tie shall be positioned on the side of the bracket opposite the side on which the cables or wires are run.
- 4.4.15. Cable ties shall not be used for banding or securing fiber optic cables/jumpers or any communications cables.
- 4.4.16. Multi-Fiber cable counts (24 and larger) no longer require the placing of sheet fiber paper as a means of protection (encircling each cable before it is secured with No. 9 lacing cord) against POI ironwork (e.g., cable rack and auxiliary framing). Standard

lacing requirements, however, still do apply to these cables at every fourth cross strap on horizontally-positioned cable racks and at every cross strap on vertically-positioned cable racks. Single fiber optic cables and smaller multi-fiber cable counts (< 24) will still require the placing of sheet fiber paper for protection at the same securing points listed above.

- 4.4.17. Secure and support all cables before, at, and after turns or junctions of horizontal runs.
- 4.4.18. Cable shall not be unsupported for a distance greater than three sheath feet, measured from the last support on the cable rack or waterfall to the first support on the frame, bay, relay rack, or vertical fiber management system unless otherwise specified in Standard Configurations, specifications or drawings.
- 4.4.19. Distributing frame cabling requires the securing of all cables on first and every alternate transverse arm, at break-off points, turns, and at the terminal strip location. Cables secured to horizontal transverse arm shall be secured in accordance with Table 4-2 below. Transverse arms on the horizontal side of the distribution frame shall have their cabling equally distributed across the served area. Cables are butted on the transverse arm at the point of break-off. Cables shall be secured using No. 9 waxed cord or equivalent.

**Table 4-2: Distribution Frames Cable and Wiring Securing**

<b>How To Identify Need</b>	<b>Securing Guidelines</b>
On transverse arms 5" or less	Secure cable sheath within 1/2 inch of butt
On transverse arms 5" to 12" in length	Secure cable sheaths within 1/2 inch of butt
On transverse arms greater than 12"	<ol style="list-style-type: none"> <li>1. Secure at cable turn</li> <li>2. Secure at cable butt location</li> <li>3. Secure midway between butt and turn</li> </ol>
Frame vertical side	Sew cables at alternate transverse arms
Unsupported drop at bottom or top of frame	Maximum cable distance 3 sheath feet
Distribution of fanning rings	No additional support required
Wires that cross under a transverse arm at cable butt	Requires a fanning ring instead of butt fiber

- 4.4.20. Power cables (Battery and Battery Return) on unsecured cable racks shall be closely coupled/paired and secured together at 12-inch intervals.
- 4.4.21. Cables from the rectifiers to the battery, charge/discharge bus, between the battery stands and from the batteries to the distribution panels shall be on a separate cable rack, or on standoffs separated from all other cables as per the approved individual POP design. These cables shall be referred to as UNFUSED POWER CABLES.
- 4.4.22. Power (battery and battery return) cables shall be supported within 12 inches of a point of termination.
- 4.4.23. Power alarm and monitoring leads run within POI locations only may be secured directly to cable rack stringers with No. 9 cord. The use of metal securing clips, and/or nylon (or other) tie wraps, on cable rack stringers or auxiliary framing for securing these leads is prohibited. Refer to Figure 4-1: Typical Cable Transition, for example.

- 4.4.24. Grounding conductors 1/0 AWG and smaller may be secured directly to the side of cable racks.
- 4.4.25. Grounding conductors larger than 1/0 AWG should be suspended on and secured to cable hangers. Cable hangers should be placed at maximum eighteen inch intervals (see Table 4-3 below).
- 4.4.26. Individual p-wire (16-26 AWG) alarm leads may be sewn on the outside of the rack or to the outside of hangers.
- 4.4.27. Cable and wire securing requirements are further defined in Table 4-3 below:

**Table 4-3: Cable Securing Requirements**

Size of Wire	Sew at Strap	# Twine Strands	Ultimate # of Layers	Cables per Stitch
<b>Sewing Horizontal Resting Runs Resting On Power and Cable Racks</b>				
400 kcmil or Larger	Every 4 <sup>th</sup>	4	Limited to 1 in <sup>2</sup>	2
250-377 kcmil		2		4
4/0 and Smaller				1
Fiber cable (wrapped with fiber sheeting)	Every 6 <sup>th</sup>	2		6, Not to exceed 2 in <sup>2</sup>
Cat3 / Cat5, etc. cable				
<b>Sewing Vertical or Inverted Horizontal Runs Resting On Power and Cable Racks</b>				
250 kcmil or Larger	Every Strap	4	Limited to 1 in <sup>2</sup>	1
4/0 - #4		2		2
#6 and Smaller				Not to exceed 2 in <sup>2</sup>
Cat3 / Cat5, etc. cable	Alternate Strap			4, Not to exceed 2 in <sup>2</sup>
<b>Sewing on Horizontal Runs of Cable Hangers Spaced at 18" Intervals</b>				
250 kcmil or Larger	Every Hanger	2	Limited to 1 in <sup>2</sup>	1
4/0 and Smaller				2, Not to exceed 2 in <sup>2</sup>

- 4.4.28. Refer to Appendix G: Cable and Wire Lacing Techniques (9-wire or equivalent) for detailed specifications on proper lacing techniques. The Installer must adhere to the lacing techniques described in this Appendix.

4.5. Cable and Wire Pile-up Guidelines

- 4.5.1. All cabling and wiring shall be run within the confines of the cable rack stringers and shall not be run so as to block access to the entrance of a bay. Do not run cables on existing cable racks where cable pileup exceeds cable pile-up limits or the top of cable stand offs. Cable stand offs are limited to a maximum usable length of twelve inches.
- 4.5.2. Vertical run cables are limited to 12 inches of pile up for cable racks 12 inches and larger.
- 4.5.3. The maximum pile-up for cable and wiring is given in Table 4-4 below:

**Table 4-4: Cable and Wire Pile-up on Horizontal Cable Rack**

Width of Cable Rack	Maximum Pile-up Height	
	Supports on 5' 1" Centers	Supports on 6' 0" Centers
12" or less	Equal to width of Rack	
15" to 25"	12"	10"
30"	10"	7"

4.5.4. The maximum pile-up on cable hangers or "T" bars shall be limited to 2 1/2 inches. One-inch cable minimum clearance shall be maintained between hanger and supporting cable rack stringer. The maximum pile-up on cable brackets shall not exceed the manufacturers recommended weight restriction or the width of the bracket whichever is more stringent.

4.5.5. Coaxial cables may be run with other types of cable. Where possible, coaxial cables should be bundled and segregated to increase protection.

4.6. Power Cable Pile-up Guidelines

4.6.1. The maximum pile-up on vertical and horizontal "Power Only" cable rack shall not exceed 7 inches.

4.6.2. The maximum width of horizontal and vertical dedicated power cable rack shall not exceed 20 inches before converting to a reinforced cable rack. Any dedicated power cable rack 25 inches in width or larger shall be a reinforced cable rack. All power cable rack shall be solid stringer type only.

4.6.3. The maximum pile-up for power cable is given in Table 4-5 below:

**Table 4-5: Power Cable Pile-up on Horizontal and Vertical Cable Rack**

Width of Cable Rack	Maximum Pile-up Height	
	Supports on 5' 1" Centers	Supports on 6' 0" Centers
12" to 20" (Solid Stringer Only)	7"	7"
25" to 30" (Reinforced Only)	7"	7"

4.7. Fiber Cable Pile-up Guidelines

4.7.1. The maximum Fiber optic cable trough capacity pileup, by duct size, are given in Table 4-6 below:

**Table 4-6: Fiber Optic Cable Trough Pile-up**

Fiber Guide Size	Duct Pileup in Inches	Quantity 1.7 mm Cables	Quantity 2.0 mm Cables	Quantity 3.0 mm Cables
2" x 2"	2	480	360	160
	2	960	720	320
2" x 4"	3	1440	1080	480
	4	1920	1440	640
2" x 6"	2	1440	1080	480
	3	2160	1620	720
	4	2880	2160	960
2" x 12"	2	2880	2160	960
	3	4320	3240	1440
	4	5760	4320	1920

- 4.7.2. The pileup estimates in Table 4-6 above are based on the following assumptions:
- Fiber cable quantities listed above are laid straight within the duct to obtain the maximum capacity available.
  - Fiber cables are singles or small “duals” only.
  - These estimates apply only to horizontal sections of fiber management system.
  - All fiber cables placed in the trough are the size indicated.

4.7.3. The maximum pile-up for riser type fiber cable is given in Table 4-7 below:

**Table 4-7: Fiber Optic Riser Type Cable Pile-up on Horizontal and Vertical Cable Rack**

Width of Cable Rack	Maximum Pile-up Height	
	Supports on 5' 1" Centers	Supports on 6' 0" Centers
5 Inches	5 Inches	5 Inches
12-20 Inches	7 Inches	7 Inches

4.8. Repair of Damaged Cables

- 4.8.1. Damaged outer jackets of Polyvinyl Chloride (PVC) covered cables shall be repaired with electrical tape. The tape shall be applied in two half-lapped layers with the final two wraps applied without tension and overlapping. The tape shall extend a minimum of two inches past the damaged section.
- 4.8.2. Seriously damaged sections of outer jackets of PVC covered cables shall be repaired by removing the damaged section and replacing it with the covering from a similar cable. Apply a single half-lapped layer of electrical tape over the new section, extending two inches to either side of the repaired section, to secure it in place.
- 4.8.3. Damaged outer jackets of power cable shall be repaired with insulation equivalent to that of the original insulation or with an insulating device identified for the purpose. Heat shrink tubing and/or electrical tape are approved for this use.
- 4.8.4. A run of cable shall be replaced if the number of damaged conductors exceeds five percent of total conductors.

- 4.8.5. Repair of damaged fiber cables must be evaluated (for loss characteristics) to insure proper operation after repairs.

#### 4.9. Spliced Cables, Splicing Systems, and Mated Connectable Cables

- 4.9.1. Splicing of any type of cables shall be kept to a minimum and, if required, shall be done at the equipment shelf or approved splice shelf. All splices shall be protected. Splices shall not appear on the cabling surface of cable racks.
- 4.9.2. Mating of connectable cables shall be kept to a minimum and if required shall be done at the equipment shelf. Connectors shall not appear on the cabling surface of a cable rack and only in the vertical upright of frames, bays or cabinets.
- 4.9.3. Mated connectable cables shall be mated and secured by using twine, tie wraps, hook and loop systems, screws, spring clips, clear heat shrink etc.
- 4.9.4. Protective covers or caps shall be installed on unused connectors to protect contacts from mechanical or ESD damage.

## 5. Fiber Optic Cable

### 5.1. General

- 5.1.1. Fiber Optic Intra-office Riser cables and jumpers shall not be pulled or twisted during installation. Fiber cable (12 fiber and smaller) must be bundled together and loosely secured every 6' along horizontal cable support systems to prevent coiling or snagging. Manufacturers' guidelines regarding bend radius shall be followed at all times where these requirements are more stringent than those listed in this chapter.

### 5.2. Installation Guidelines

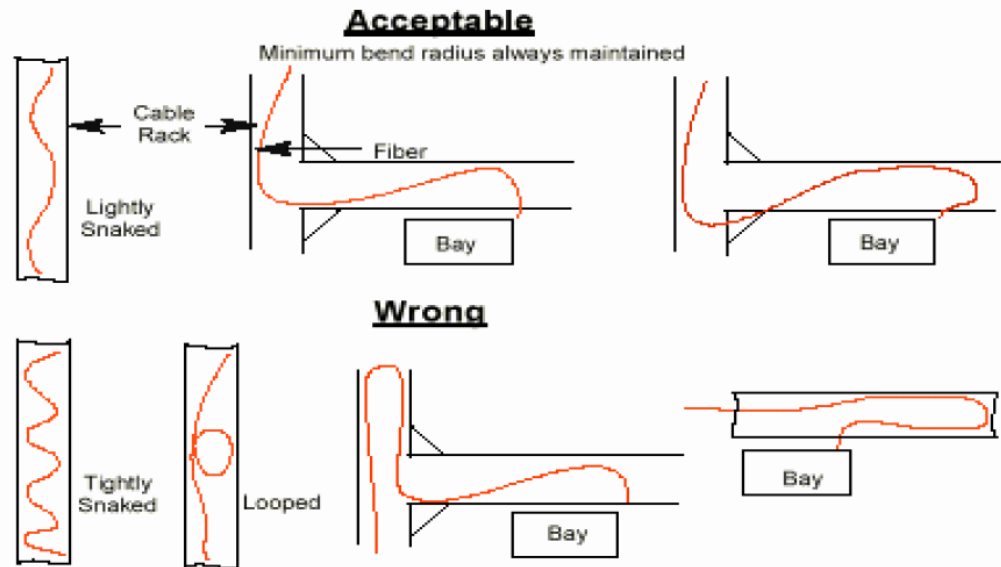
- 5.2.1. Fiber Optic Cable slack storage or looping within dedicated, segregated fiber-only cable racks or fiber management system-type protection systems is prohibited. Fiber optic cable slack shall be stored in approved slack storage panels and facilities only. Fiber jumper slack shall be stored on reels or trays, specifically designed for that purpose. Slack lengths stored in the horizontal fiber management system or on the "Fiber Optic Cable Only" cable rack shall not be looped and will adhere to the following examples:



**Fiber Cable  
Rack Slack  
Installation  
Examples**

Approved Methods:

- The **first** choice for installing fiber optic cables is to lay the cables within the fiber cable rack or duct support systems in a straight line enabling utilization of the maximum capacity of fiber support systems.
- There are ways to manage the acceptable slack limits within cable racks. The examples below depict acceptable and unacceptable methods of consuming the fiber cable slack limits documented herein:



5.2.2. Acceptable fiber cable slack limits within horizontal sections of the fiber management system or “Fiber Only Cable” rack will be equal to or less than those stated in tables 5-1 and 5-2 below:

**Table 5-1: Maximum Fiber Cable Slack Lengths (Within “Fiber-Only Cable Racks”)**

Run Length in Meters	Run Length in Feet	Maximum Slack in Feet (Meters)
1-15	~3.3’ to ~50’	2’ (~.6m)
16-25	~53’ to ~82’	3’ (~.9m)
26-50	~85’ to ~164’	5’ (~1.5m)
51-75	~167’ to ~246’	7’ (~2.1m)
> 76	>~250’	10’ (~3m)

**Table 5-2: Maximum Fiber Cable Slack Lengths (Within “Fiber Management Systems (ADC or equivalent))**

Run Length in Meters	Run Length in Feet	Maximum Slack in Feet (Meters)
1-15	~3.3’ to ~50’	1’ (~.3m)
16-25	~53’ to ~82’	2’ (~.6m)
26-50	~85’ to ~164’	3’ (~.9m)
> 76	>~167’	5’ (~1.5m)

- 5.2.3. Metallic type fiber optic cables shall be grounded. Components include: protective cable covering, cable sheath and/or any metallic inner strength members.
- 5.2.4. All 90-degree corners used to route and support fiber cables on “FIBER OPTIC CABLE ONLY” cable racks must be equipped with corner brackets. Fiber cables are routed around the corners using the approved corner brackets.
- 5.2.5. All fiber management systems will be dedicated to support fiber optic cables only. Use of ADC or similar fiber management system is approved (Refer to Figures 5-1 and 5-2 below).

**Figure 5-1: ADC Fiber System – Straight System - 90° Bend**



**Figure 5-2: ADC Fiber System**



- 5.2.6. All covers and devices used to maintain fiber cable/jumpers within their horizontal and vertical protective duct systems shall be in place and secure. The use of “split flex” tubing is only approved for short transition (24 inches or less) applications from horizontal solid duct to vertical slotted duct on equipment frames. Horizontal runs of

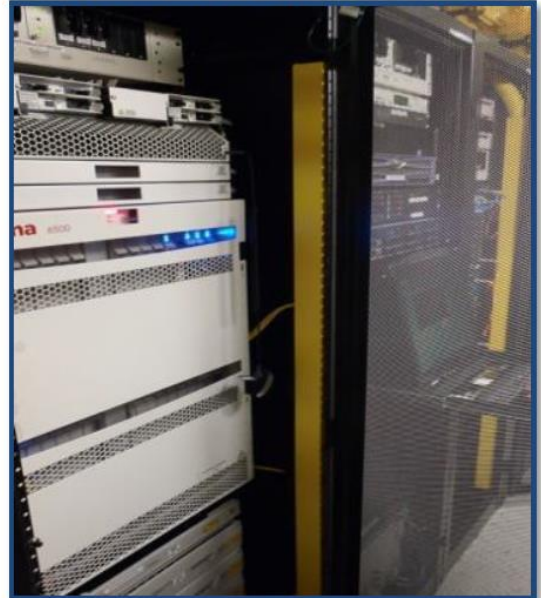
split flex tubing are strictly prohibited. Horizontal sections of fiber trough shall be supported as follows: 2"x 2" slotted = 18 inches; 2"X 2" solid = 24 inches; 4" X 4" solid = 5 feet.

- 5.2.7. Vertical fiber cable rack will be installed using plastic pan with cover on the sides of cabinets and relay racks. Refer to (Figures 5-3 and 5-4 below).

**Figure 5-3: Vertical Fiber – FDP**



**Figure 5-4: Vertical Fiber - Ciena**



- 5.2.8. The vertical fiber cable itself must be manually wrapped with sheet fiber paper and securely tied with No. 9 cord to every cable rack cross strap to secure the cable on vertical runs. Fiber optic inter-office "MIC" type cable will be laid in cable rack unsecured.
- 5.2.9. End caps are required on the end of all horizontal or vertical fiber system sections.
- 5.2.10. Running fiber optic cables or patch cords with any other type of cable is prohibited. Fiber jumpers and cables will be run in either an approved fiber protection system or on dedicated, segregated cable rack per the guidelines shown in Table 5-1 below:

**Table 5-1:**

Fiber Optic Cable / Jumper Type	Shall be run in a Fiber Protection System	Shall be run on Fiber Cable Rack
OFN type Fiber Jumpers	Yes	No (Note 1)
OFNR / OFNP Type Fiber Cable: 1 fiber	Yes	Yes (Note 3)
OFNR / OFNP Type Fiber	Yes (Note 2)	Yes (Note 3)
Cable: 2 to 12 fibers		
OFNR / OFNP Type Fiber Cable: over 12 fibers	No	Yes

- 5.2.11. Table 5-1 Notes:

- Fiber patch cords/jumpers shall not be run commingled with larger type fiber optic cables. The weight of the larger cables has the potential to cause service-disrupting micro bends in the smaller patch cords/jumpers.
- Small quantities of fiber optic cables (10 cables or less total) containing between 4 – 8 fibers/cable may be run in the fiber management system where existing office conditions prevent the installation of a cable rack system (or where the maximum quantity of 10 cables would not be exceeded).
- Multiple groups of single or dual OFNR fiber cables may be run on dedicated, segregated panned and bracketed orange fiber-only cable rack when the small fiber cables are bundled together by wrapping the fiber cable group with sheet fiber paper and loosely security them with No. 9 cord every 5' to 6' within the ladder [panned and bracketed] orange cable rack.
- Care must be taken to ensure that small fiber cable bundles remain undamaged on the cable rack. Where possible, segregate the fiber cable bundles from larger cables within the cable rack and limit instances where large cables cross over smaller cable bundles.

## 6. Wiring

### 6.1. General Requirements

- 6.1.1. All equipment installed shall have the all wiring run and terminated to the locations specified using the type, color, and gauge specified in the drawings/records and/or manufacturer's specifications and instructions.
- 6.1.2. Wire shall be neatly dressed in such a manner as to avoid congestion, to ensure accessibility to the equipment, including but not limited to, all chassis cards, power supplies, cooling fans, air filters, open slots etc. and to maintain clearance between terminals. This is critical for the proper operation and maintenance of the equipment.
- 6.1.3. Wires connected in distribution frame blocks shall be dressed to allow visual inspection of terminal connections.
- 6.1.4. Wire dress shall be sufficient to provide enough wire length so they may be re-skinned and reconnected without splicing the conductor.
- 6.1.5. Wire shall be both listed and rated for the application.

### 6.2. Sowed Forms

- 6.2.1. All sowed forms shall be secured in a manner that avoids congestion and affords access to the equipment including but not limited to, all chassis cards, power supplies, cooling fans, air filters, open slots etc. and to maintain clearance between terminals. This is critical for the proper operation and maintenance of the equipment.
- 6.2.2. All wiring added to existing forms shall be neatly dressed and properly secured.
- 6.2.3. All ending stitches shall be trimmed of excess twine.
- 6.2.4. Forms designed for hinged equipment shall be capable of accomplishing movement without twisting or damage to the form.

## 7. Connecting

### 7.1. General Requirements

- 7.1.1. All connections made over solder or on terminals with soldered connections shall be soldered.
- 7.1.2. Connections made with untinned wire do not require soldering, simply because they are untinned or not plated.
- 7.1.3. All DC/grounding wire connections terminated under screw heads shall be made with an approved ring connector. "Fork" connectors are not allowed for DC power terminations.
- 7.1.4. Stranded wire shall be tinned to the extent of forming a solid conductor-end prior to being inserted into any threaded compression connector.
- 7.1.5. All single-hole and two-hole terminations for power and bonding/grounding shall require the use of a lock washer, except where double or locking nuts are standard. Use shake proof (star) lock washers under mounting screws and split ring lock washers with bolts and nuts. Lock washers shall not be placed between the connecting terminal and the contact surface.
- 7.1.6. All terminals, lugs, and connection points shall be free of contamination and previous connecting materials; i.e., corrosion, paint, grease, dirt, etc.
- 7.1.7. Plated surfaces, such as silver or lead-plated copper, etc., are plated to prevent oxidation and reduce contact resistance and, therefore, shall not be sanded or abraded. If cleaning is required, wipe with a dry cloth.
- 7.1.8. All types of connections shall be secure (tight) and shall conform to manufacturer's torque requirements where specified.

## 7.2. Crimp Compression Connectors, Splices, and Taps

- 7.2.1. All crimp compression connections using the various types of approved commercial connectors shall be properly made with the number of crimps being determined by the manufacturers' requirements pertaining to the wire gauge, type of wire, type of lug, and the crimp compression tool used.
- 7.2.2. The connector specified or used shall determine the crimp compression tool and die set combination required. Wires shall be inserted to the full depth of the lug. The wire shall be inserted to within 1/8 inch of the inspection hole for wire sizes No. 2 AWG and smaller and within 1/4 inch for wire sizes No. 1/0 AWG and larger.
- 7.2.3. The space between the wire insulation and the bodies of connectors and lugs shall be kept to a maximum of one eighth of an inch. Field prepared connections must use transparent (clear) heat shrinkable tubing when insulation is required to protect the connector from shorting and/or the connector barrel extends beyond the edge of a protective cover. The use of any other color of heat shrinkable tubing is prohibited. Reference Figure 7-1 below:

**Figure 7-1: Ground Collection Bar Terminations**



- 7.2.4. All connections shall be accessible for inspection. Power conductor H-taps shall be taped with plastic electrical tape, have covers applied, and the covers secured with 9 cord. Ground connections made with C-taps/H-taps do not require protective covers.
- 7.2.5. All connections shall be free of sharp edges, fins, or burrs caused by the crimping process. Crimps shall not extend onto the tang area. Individual crimps may not be re-crimped after initial application. Only one wire shall be crimped in a connector barrel.
- 7.2.6. Compression crimps shall be permitted on solid wire, 16 gauge and smaller, and on solid No. 2 AWG tinned copper conductors used specifically for internal connections to the ring ground system. Connectors used on solid No. 2 AWG shall be specifically intended for use on solid wire.
- 7.2.7. Parallel H-tap or C-tap connector covers for battery and battery return cables shall be secured with No. 9 cord. The crimped connectors will be wrapped in plastic electrical tape prior to the covers being installed. Parallel connectors shall not be located on cable rack cross-straps, stringers, vertical runs or any other metallic object, which will cause pressure to be exerted on its protective cover. Parallel connectors shall be located (and staggered) within the space between cable rack cross-straps when run on the lowest cable layer and are permitted on the cable rack.
- 7.2.8. Parallel connectors that have a different voltage potential than frame ground shall be plastic taped to prevent accidental contact to ground.
- 7.2.9. Butt or reducing splices for power connections are required to be insulated with clear heat shrinkable tubing. Butt or reducing splices for grounding connections are not required to be insulated.

### 7.3. Fiber Optic Cable / Fiber Optic Jumper Testing

- 7.3.1. Installers shall always clean all fiber connectors thoroughly before making the connection with the mating adapter of an FDP. Very small particles can permanently damage the end of the mating fiber inside the patch panel, which makes regular cleaning imperative.
- 7.3.2. When cleaning a paired cable connector (bulkhead mating adapter), always clean the mating adapter first. Specially built fiber cleaning sticks come in 2.5mm and 1.25mm versions. They are designed for dry cleaning fiber optic connector mating sleeves, bulkhead adapters and receptacles. Semi-Automated fiber cleaning tools are also available for this purpose. Do not clean bulkhead receptacles without a means of inspection following the cleaning. The attempted cleaning could easily make the condition worse.
- 7.3.3. Proper use of fiber cleaning kits is essential for fiber jumper preparation prior to connecting to the equipment or FDP. A Type A Fiber Cleaning Kit shall be used for all SC, ST, FC (2.5mm) fiber connectors. A Type B Fiber Cleaning Kit shall be used for all LC or MU (1.25mm) fiber connectors.
- 7.3.4. All fiber connections shall be inspected prior to connecting to the equipment or FDP. At a minimum a Fiber Scope shall be used to verify that both Zone A (Core) and Zone B (Ferrule) are clear of debris prior to making a connection to the equipment or FDP.
- 7.3.5. In order to minimize the possibility of incorrect fiber optic cable / jumper termination, the Installer will perform, at a minimum, a basic continuity test on installed fiber optic cables & jumpers with an Optical Loss Meter (OLM). This device is also referred to as a "light meter." Fiber optic cables within a stored program control system (e.g., electronic

- switching) that are tested by manufacturer's requirements, are exempt from this procedure.
- 7.3.6. Unconnected fiber connectors, including but not limited to equipment ports, fiber patch cord connectors, and FDP bulk head connectors, shall always have dust caps installed.
  - 7.3.7. Unused dust caps shall be stored in a re-sealable bag to prevent dust accumulation.

## 8. Power

### 8.1. General Requirements

- 8.1.1. All connectors, wiring, conduit, fixtures, etc. shall meet the requirements of the National Electric Code (NEC), National Electrical Manufacturer's Association (NEMA), and Underwriters' Laboratories (UL).
- 8.1.2. Installers engaged in the installation, removal, or modification of live power equipment shall protect exposed live conductors, busbars, adjacent equipment, etc. with power insulating blankets. Materials other than power insulating blankets shall not be used.
- 8.1.3. No work shall be performed on LIVE AC Circuits by anyone other than a Qualified Electrician. Since most AC circuits and some DC circuits can be worked on with the energy removed, the MOP shall contain the reason for working on any live AC circuits. For AC circuits that can be de-energized, lock-out / tag-out procedures must be followed.

### 8.2. Primary and Secondary Distribution

- 8.2.1. Run all leads in continuous lengths per job specification. The use of "in-line" drop splices or H-tap connections does constitute "continuous length" runs.
- 8.2.2. DC wire for distribution and grounding shall be TelcoFlex II, rated for 600 volts, copper conductor, Class 1 flexible strand without braid non-halogenated wire. This requirement applies to all DC power conductors that are 14 AWG and larger. The color of -48V & RTN (DC) power leads is typically gray (with a blue tracer for non-halogenated without a cotton braid cover) or black (with a red tracer for non-halogenated without a cotton braid cover). Grounding conductors shall be green (and can be made with a yellow tracer, which is required, for non-halogenated without a cotton braid cover) or bare.

**Note:** All Telcoflex wire does not require a cotton braid or to be fiber-wrapped (due to "cold flow") at lacing points on cable rack straps. Also, it is not required that this cable be tinned when it is run outside the power room, since there are no halogenic or sulfuric compounds to oxidize and corrode the copper. Unfused power leads must be tinned.

- 8.2.3. All battery and battery return cables shall be run closely coupled and in pairs (except for at the termination ends, and for return conductors running past remote ground windows, which must be paired back on themselves).
- 8.2.4. Power cables (Battery and Battery Return) run on panned racks shall be paired and secured together at 24- inch intervals. ("Paired" is defined as placing these cables above/below or at the side of each other and securing with a No. 9 cord lock stitch such as would be done when sewing on power cable rack with existing conductors).
- 8.2.5. Where space does not permit the addition of a separate, dedicated power cable rack, power cables protected with 70 amp or less fuses / breakers may be run on cable racks if they are sized at No. 4/0 AWG or smaller. All power cables larger than No. 4/0 AWG regardless of fuse / breaker size shall be run on dedicated FUSED POWER CABLE ONLY

cable racks or standoffs as approved by the individual POI design. The placement of any type of cable used for anything other than power on FUSED POWER CABLE ONLY racks or standoffs is prohibited.

- 8.2.6. Primary DC power distribution cable shall be run on a dedicated DC power cable rack or standoff as approved in the individual POI design. Primary DC power distribution is defined as leads from the power plant to the BDFB or the power distribution frame dedicated to a switch. Secondary DC power distribution is defined as power from the BDFB to the equipment. Primary and secondary power leads are not to be segregated and can be run commingled on the same dedicated power cable rack.
- 8.2.7. When secondary power cable is tapped down for entry into equipment frames, taps shall be placed on the cable rack between cable rack straps, and staggered above or within six feet of either side of the frame, bay, or cabinet.
- 8.2.8. All tap connections shall be accessible for inspection. Connections that are taped and have covers applied shall be considered accessible. Heat shrinkable tubing, other than clear, is not considered accessible.
- 8.2.9. Main conductors and feeders in the plant should be sized for the ultimate capacity of the plant.
- 8.2.10. Unfused Cables from chargers to batteries and from batteries to discharge panels or bus assemblies shall be on a separate cable rack from all other cables. Power conductors that run from the battery string to the power board are considered unfused leads.

### 8.3. Battery Primary Conductors

- 8.3.1. On new installations of primary DC power, the cable shall not share a cable rack with any other type cable and shall be run on dedicated DC power cable rack or standoffs as approved on the individual POP design.
- 8.3.2. All battery and battery return cables shall be run closely coupled and in pairs with the following exceptions:
  - This "pairing" requirement does not apply to cabling between the power plant and batteries and/or primary distribution board, or the cable within a few feet of the return bus of a secondary distribution center — e.g. BDFB.
  - Between the bays and/or battery stands, internal to the power plant, paired battery and return are preferred. However, unpaired leads are allowed internal to the power plant under the following conditions: They are run as closely as possible; No other cables are placed between them; and No non-referenced (ungrounded) equipment is within ten (10) feet.
  - The battery return leads are not to be confused with the grounding conductors and shall not be marked or otherwise identified with the color green. Nor should they be colored red unless that is the color from the manufacturer in a winning harness.
  - Should it be required to run DC conductors inside of a conduit then both the battery and battery return shall be paired within the same conduit.

### 8.4. Busbars

- 8.4.1. Busbars shall be free of sharp edges, burrs, corrosion, etc. and shall be copper or tin-plated copper.
- 8.4.2. Busbars shall be properly supported per drawings/records and insulated from surrounding metal work.



- 8.4.3. A metallic coating or plating is sometimes used on busbars to reduce the resistance of the connecting joints. These contact surfaces should be cleaned with a clean, dry cloth to remove grease and other foreign matter, but should not be sanded or the surface otherwise scratched. Non-plated copper bars shall have connection points cleaned. See Section 3.6, "Bolts, Nuts, Screws and Threaded Rod Guidelines," and Section 7, "Connecting."
- 8.4.4. Install a pal nut or locknut on each busbar clamp bolt. Verify that regular nuts are tight before applying the pal nuts or locknuts. Reference Figure 7-1: Ground Collection Bar Terminations.
- 8.4.5. Ferrous bolts, screws, nuts, washers, busbar supports and clips used in fastening copper to copper, or combinations of metals shall be zinc or cadmium plated; however, copper, copper plated, tin-plated copper and stainless steel parts may be used as per the approved individual POP design.
- 8.4.6. Busbars which are located external to an equipment framework enclosure, and have a potential different than the surrounding or supporting metal work shall be protected from short circuits by means of an insulated removable cover.
- 8.4.7. Busbars requiring protective covers:
- All battery busbars and splice plates not located within a framework enclosure.
  - Battery return splice plates where the potential of the plates are associated with an isolated ground plane, but are physically located and/or supported from ironwork associated with the integrated ground plane.
- 8.4.8. Busbars that do not require protective covers:
- All bus bars or splice plates located on a battery stand unless they present a safety or service hazard.
  - Battery return distribution bars located above a BDFB. Even if the power source feeding the BDFB is used to power a SPCS, the BDFB should appear subsequent to the Ground Window; therefore, contact between the return bus bar and surrounding metalwork would not constitute a single point ground violation.
  - Busbars used as the Main Grounding Bar (MGB). This is the point of interface between the two ground planes (commonly referred to as the Ground Window). Therefore, accidental and / or additional contact with either ground member would have minimal effect.
  - Busbars that are used as a grouping point to bond integrated ground members together or to the MGB when required.
- 8.4.9. All busbars shall be a minimum of 3 inches from any metal objects. Where this separation cannot be achieved, insulation must be provided between the busbar and the metallic object.
- 8.4.10. All busbars shall be installed so as to afford ready access to the connecting surface (minimum of 4 inches of clearance).

#### 8.5. Power Connections

- 8.5.1. Electrical resistance shall be kept as low as practicable.
- 8.5.2. Contact surfaces shall be cleaned so that direct metal to metal contact is made. Nonconductive coatings (such as paint, lacquer and enamel) on equipment shall be completely removed under the entire contact surface to assure good electrical continuity. Copper bars may require the use of low abrasive pads to remove oxidation.

- 8.5.3. Plated surfaces, such as silver or lead plated copper, etc., are plated to prevent oxidation and reduce contact resistance and, therefore, should never be sanded or abraded. If cleaning is required, wipe with a dry cloth.
- 8.5.4. Mating surfaces shall be flat to ensure maximum cross-sectional area contact.
- 8.5.5. A non-oxidizing agent shall be applied to inhibit corrosion on all battery, battery return, and grounding connections, i.e. at all contact points, bolts, washers, nuts, "H" taps, "C" taps, lugs and other items. This non-oxidizing agent is an insulator, so only a thin coat should be applied.
- 8.5.6. All pressure or clamping devices shall be tight.
- 8.5.7. DC power, return, and bonding/grounding lead connections shall have lock washers installed to ensure secure connections. Use shake proof (star) lock washers under mounting screws and split ring lock washers with bolts and nuts, except where double or locking nuts are standard. Lock washers shall not be placed between the connecting terminal and the contact surface.
- 8.5.8. Connections that require annual re-torquing routines shall not be used. Battery inter-cell connectors are exempt from this requirement since they require annual re-torquing.
- 8.5.9. Attach only one lead to a punching, lug or connector that is designed to accommodate one lead.
- 8.5.10. Attach only one connector with the same mounting screw(s) or bolt(s) unless specified in the associated equipment AMC configuration. Frame ground connectors, chassis, shield, and equipment bonds shall not be stacked one on top of the other under the same mounting hardware.
- 8.5.11. Any connector drilled with two holes shall be secured using both holes.
- 8.5.12. On BDFB and Power Boards all alarm wiring for power fuses and associated alarm fuses shall be connected initially whether the locations are to be fused or to be made spare.
- 8.5.13. Stranded cables shall retain all of their strands at the point of termination.
- 8.5.14. All connectors with a potential other than ground shall be protected if they extend out beyond a protective cover and if they are within 3 inches of any differing potential. Suitable protection shall be clear heat shrinkable tubing or one wrap of sheet fiber paper.
- 8.5.15. DC power connections for supply and return shall use irreversible crimp-type copper connections, wire wraps, or latching "plugs". Aluminum connectors shall not be used, and set-screw connections are not allowed. DC power connections to non-service-affecting equipment (e.g., indicating lights, alarm equipment) are exempt from this requirement.
- 8.5.16. Internal to the supplier's equipment, power connections types are the prerogative of the equipment manufacturer.
- 8.5.17. DC power connections between the source fuse panel and the shelf can be a one-hole or two-hole crimp, wire wrapped, or latching "plug" depending on equipment design.
- 8.5.18. All connections to a battery return busbar must be a two-hole crimp only. These connections should be stacked (one above and one below the return busbar) to conserve space. Exceptions to the "two-hole" requirement are allowed for battery return busbars in DC plants rated at 50 Amperes or less.
- 8.5.19. All connections (nuts and bolts) made to battery posts, terminal plates, and inter cell connectors shall be made with silicone bronze (preferred), stainless steel, lead, or lead-coated copper. All compression type lugs are required to have inspection holes.
- 8.5.20. There will be no connectors varnished, lacquered or painted, during or after installation.

- 8.5.21. Heat shrink tubing that does not provide a hermetically sealed connection will not be allowed. Only clear heat shrink tubing may be used.
- 8.5.22. The integrity/quality of a crimp connection is dependent upon the following:
- The correct size connector for the particular wire size(s) involved;
  - Insulation removed so that the wire extends the full length of the barrel or groove;
  - Preparation of the wire end and connector as required;
  - The use of a non-oxidizing agent on the wire and in the connector as required;
  - Full insertion of the wire into the connector. The wire shall be inserted to within 1/8 inch of the inspection hole for wire sizes No. 2 AWG and smaller and within 1/4 inch for wire sizes No. 1/0 AWG and larger;
  - Compress the connector the correct amount and in the proper sequence using the lug manufacturer's recommended tool and die set.
- 8.5.23. Mechanical connectors shall not be used in DC power distribution and grounding systems.
- 8.5.24. All electrical connections shall be smooth and treated with a non-oxidizing agent.
- 8.5.25. Parallel taps for branching or frame entry on power and grounding conductors shall be equal to or smaller than the feeder conductor being tapped.
- 8.5.26. Battery and battery return connections made with H-taps require the connection to be taped, a cover applied, and secured with No. 9 cord.
- 8.6. Fuse Bays, BDFB's, Power Boards, etc.
- 8.6.1. All fuses and circuit breakers shall be of the proper type and capacity specified in job drawings/records and shall be in compliance with manufacturers' design specifications. **Cable ampacity shall equal or exceed the protecting device size.** When manufacturers specify multiple loads (A&B, etc.) they shall be fused from different power board feeders. Fuses shall be installed or breakers turned on at the completion of the job to identify the correct polarity of the connection at the fuse panel, and test records shall be provided.
- 8.6.2. Lock Out/Tag Out warning labels shall be used on all DC circuits that are connected to the distribution source and are not energized at the time of termination.
- 8.6.3. All cartridge, knife type fuses, and fuse reducers being installed shall be cleaned and lubricated with a non-oxidizing agent.
- 8.6.4. A non-oxidizing agent shall be applied to inhibit corrosion on all battery, battery return, and grounding connections.
- 8.6.5. Dummy fuses shall be installed where fuse holders depend on the dummy fuse as tensioning agents. Dummy fuses are not required at all unassigned fuse locations.
- 8.6.6. Fuse reducers shall not be used in "dead front" fuse panels. Dead front is defined as having no exposed electrical potential. Fuse reducers shall not be used to reduce the fuse size more than once (double reducers).
- 8.6.7. All unassigned circuit fuses, their designations/pins, and associated alarm fuses shall be removed. Dedicated alarm fuse designation pins may remain in place.
- 8.6.8. All "live front" power distribution bays designed to have front protective covers, shall have those covers installed. Live front is defined as having exposed electrical potential.
- 8.6.9. All unequipped fuse/breaker block positions or panels shall have blank panels installed. No holes shall be permitted.
- 8.6.10. The largest fuse permitted in a BDFB is 100 Amps, and only if the BDFB will accept that size of fuse (in some cases, use of these larger fuses may require sparing of the next and/or previous position due to heat per the manufacturer requirements).

- 8.6.11. No cable larger than a No.1/0 AWG shall be terminated to a BDFB fuse position. Larger distribution cables shall be tapped down to a maximum of a No. 1/0 AWG before entering the BDFB. For miscellaneous-mounted fuse panels in relay racks, no cable larger than a No. 4 AWG shall be terminated on the rear entry of the panel (unless the source amperage and/or manufacturer's specifications warrants a larger size).
- 8.6.12. When power cables are tapped down in size for entry, taps shall be placed within six feet of the entry point into the BDFB (15' for PBDs). Taps shall be staggered to prevent pileups (reducing splices do not have to be staggered).
- 8.6.13. All tap connections shall be accessible for inspection. Connections that are taped and have covers applied shall be considered to be accessible. Heat shrinkable tubing, other than clear, is not considered to be accessible.
- 8.6.14. Equipment loads on a BDFB feeder, shall never exceed 50% of their fused value.
- 8.6.15. Only DC type fuses and breakers shall be used for DC circuits. Only AC type fuses and breakers shall be used for AC circuits.
- 8.6.16. No circuits shall be energized without both ends of the circuit identified and connected.
- 8.6.17. When 500V-rated insulation (minimum) is **not** used on conductive members of differing potentials, those conductors must be separated by at least 2 inches of air space.

#### 8.7. Fuse Contact Preparation and Protection

- 8.7.1. Fuse ferrules, blades, and contact area of their associated clips shall be coated with a thin film of a non-oxidizing agent.

#### 8.8. Wire Information Table

- 8.8.1. The cable is sized by the Installer for ampacity and voltage drop. The Installer is responsible for verifying that the circuit protection device is sized correctly for the cable. Refer to Table 8-1 below for Cable Sizing information.

**Table 8-1: Cable Sizing**

Wire Size	Cable / Wire Information				
	AMPS*	Circular Mills	Weight Per Ft.	Diameter over Insulation	Bend Radius
14 AWG	15	4,110	0.026#	0.19"	1.71"
12 AWG	20	6,530	0.035#	0.21"	1.89"
10 AWG	30	10,380	0.049#	0.24"	2.16"
8 AWG	40	16,510	0.084#	0.31"	2.79"
6 AWG	55	26,240	0.126#	0.40"	3.60"
4 AWG	70	41,740	0.190#	0.45"	4.05"
2 AWG	95	66,360	0.275#	0.51"	4.59"
1/0	150	105,600	0.443#	0.63"	5.67"
2/0	175	133,100	0.540#	0.68"	6.12"
4/0	230	211,600	0.814#	0.75"	6.75"
350 KCM	310	350,000	1.310#	0.98"	8.82"
500 KCM	380	500,000	1.815#	1.12"	10.08"
750 KCM	475	750,000	2.700#	1.34"	12.06"
1/0 FLEX	150	111,100	0.510#	0.66"	5.94"
2/0 FLEX	175	131,300	0.630#	0.72"	6.48"
4/0 FLEX	230	222,200	0.890#	0.84"	7.56"
350 KCM FLEX	310	373,700	1.490#	1.07"	9.63"
350 KCM FLEX	380	535,300	2.000#	1.24"	11.16"
350 KCM FLEX	475	777,700	2.900#	1.54"	13.86"

## 9. Batteries

### 9.1. Installation and Storage Requirements for Lead Acid Batteries

- 9.1.1. The recommended storage temperature is 59 degrees Fahrenheit, but the extreme allowable temperature is 32 degrees to 122 degrees Fahrenheit.
- 9.1.2. When batteries are not installed in the cabinet they must be placed on a barrier between the battery and the concrete floor. Never store batteries directly on concrete. Inspect for defective cables, loose connections, corroded cable connectors or battery terminals, cracked cases or covers, loose clamps or terminal posts.

## 10. Bonding and Grounding

### 10.1. General Requirements

- 10.1.1. All grounding conductors shall be run exposed and supported to existing cable rack, hangers, or suitable framework using nylon/plastic tie wraps or No. 9 cord.
- 10.1.2. Grounding conductors No. 1/0 AWG and smaller may be secured directly to the side of cable racks, or run along walls and secured at 18" intervals.

- 10.1.3. Grounding conductors larger than No. 1/0 AWG shall be suspended on and secured to cable hangers or run along walls and secured at 18" intervals. Cable hangers shall be placed at 18" intervals.
- 10.1.4. Grounding conductors shall not be run within cable racks or attached to AC conduit.
- 10.1.5. All connections shall be made with a crimp compression parallel copper connector (C-tap or H-tap) or a two-hole crimp compression copper / tinned copper connector. Two-hole crimp connectors shall be secured with an approved lock washer placed between the connector and the head of the screw or nut.
- 10.1.6. Grounding conductors, bonds and taps to ground conductors shall be preferably arranged to flow fault currents in the direction of the OPGPB or ground source. This rule does not apply to busbar assemblies.
- 10.1.7. 180 degree bends in grounding conductors are not permitted.
- 10.1.8. Minimum bending radius of a grounding conductor is 12 inches.
- 10.1.9. All shielded cable and wire shall be grounded at one end or as directed in the job specification, drawing/record, or manufacturers' specification.
- 10.1.10. All chassis, shield, and equipment ground bonds may be made using either a single or two-hole ring crimp connector which will be secured with an approved lock washer placed between the connector and the head of the screw or nut, not between the connector and the contact surface. Use of a single or two-hole ring connector is dependent on the equipment design.
- 10.1.11. Frame ground connectors, chassis, shield, and equipment bonds shall not be stacked one on top of the other under the same mounting hardware.
- 10.1.12. A grounding conductor shall not be secured or supported by metallic clamps which completely encircle the conductor.
- 10.1.13. Stranded RHW or XHHW type insulated copper wire, where the insulation is colored green, is the standard interior POI grounding conductor (AC grounding conductors are typically green THWN). (In accordance with the NEC, wires other than "grounding" conductors shall not be colored green, with the exception of manufacturer wiring inside a bay or shelf. For example, the "grounded" -48 VDC battery return conductor[s] shall have insulation colored gray or black. Although green coloration is recommended for smaller wires, including chassis grounds, it is not required.) Alternately, bare copper wire (stranded or solid) is also allowable in some situations.
- 10.1.14. Attachments to raceways shall only be made per NEC 300.11B.
- 10.1.15. Ground conductors shall be run so that they are visible from the floor.
- 10.1.16. Ground conductors shall be run so that they may be accessible throughout their expected life.

## 10.2. Grounding Frames, Bays and Cabinets

- 10.2.1. All frames, bays, and cabinets shall be individually grounded with a minimum No. 6 AWG green covered RHW, XHHW or bare AWG copper stranded wire.
- 10.2.2. All ground connections shall be secure.
- 10.2.3. All contact surfaces shall be cleaned and treated with a non-oxidizing agent.
- 10.2.4. Frame support pipes shall not be used for frame grounds. If necessary, the installer shall contact the Installation Supervisor to arrange for the necessary material to provide a proper No. 2 AWG stranded, insulated, copper conductor, supported on hangers, extending the full length of the lineup.

- 10.2.5. Frame, bay and/or stand extension supports (extenders) shall be bonded to the frame with a minimum No. 6 AWG conductor that shall not contain bends exceeding 90 degrees.

10.3. Equipment Chassis Shield and Quiet Grounding Connections

- 10.3.1. Chassis and shield grounds may be made using single-hole crimped compression connectors or by manufactures specifications. If a manufacturer provides a termination for a chassis, shield, or quiet ground, that bond shall be made. NEBS tested self-tapping screws and/or tooth- type lock washers are also approved for chassis grounding connections.
- 10.3.2. All shielded cable and wire intended to be provided with a quiet/shield ground, shall have its shield bonded to ground on one end or the other, but not on both ends unless specified by standard or manufacturers drawing. See Section 2, "General Requirements."

## Appendix F: Conditional Acceptance Testing

### As applicable to Scope B equipment and installation

#### 1. Conditional Acceptance Tests (Component-Level):

- a. OPM or representative and/or the Network Operator will have the option of attending all Component Level testing activities. The Contractor must provide OPM with 7 days' notice prior to commencing Conditional Acceptance Testing on specific infrastructure and components.
- b. After or during the installation of components in the field, Conditional Acceptance Tests must commence. All tests must be documented with Acceptance Test Results (ATR) forms. The tests must verify that:
  - i. The components delivered to the field meet agreed specifications.
  - ii. Installation was executed in accordance with the agreed design and construction specifications.
  - iii. Layer 0/1 specifications are met.
- c. The Conditional Acceptance Tests (Component-Level) are divided into the following functional areas:
  - i. Facilities / ISP
    1. Electrical/Power Plant Site Test – This test confirms that the electrical systems, including where applicable DC power units and generator failovers, are installed to specification and operating as per each applicable design package.
    2. Environmental Controls Site Test – This test confirms that the existing or upgraded HVAC subsystems are installed and/or operating as per each applicable design package.
    3. ISP Cabling Site Acceptance – This acceptance ensures that the inside cable plant and cable entrance are installed as per each applicable design package.
    4. OOB Site Test – This test confirms that Out Of Band connectivity is functioning as per each applicable design package (where applicable).
    5. Site Monitoring Test – This test confirms that all environment and security sensors at a specific site are installed and operating as per each applicable design package.
    6. Collocation Site Acceptance Procedure – This inspection based acceptance procedure verifies that a specific site's collocation facilities and ISP infrastructure is in place and performs as per each applicable design package.
    7. Customer Premise Site Acceptance Procedure – This inspection based acceptance procedure verifies that a specific customer premise facilities and ISP infrastructure is in place and performs as per each applicable design package.
  - ii. Electronics
    1. Installed Electronics Acceptance Test – Each electronics component installed shall have a Power On Self-Test (POST), commissioned configuration inspection, and physical installation inspection performed. The details of



acceptance tests for each element must be determined during the detailed design phase.

2. POP Electronics Acceptance Test – This inspection and test based acceptance verifies all electronics at each POP are in place and performs as per each applicable commissioning design package.
3. Customer Prem. (ONT) Electronics Acceptance Test – This inspection and test based acceptance verifies all electronics at each customer premise are in place and performs as per each applicable commissioning design package.

## 2. Conditional Acceptance Tests (Link-Level):

- a. OPM or representative and/or the Network Operator will have the option of attending all Link Level testing activities. The Contractor must provide OPM with 7 days' notice prior to commencing Conditional Acceptance Testing on specific link performance parameters.
- b. Link Performance Testing validates that all of the logical transport links, which include the electronics hardware and fiber infrastructure, meet the performance specifications detailed in the agreed Network design and base-lined during Lab System Prototype Tests. This test validates the ability of the underlying infrastructure to deliver the performance on a link-by-link basis. The results must be documented with Acceptance Test Results (ATR) forms. Please see below for an overview of the Link Performance Testing:

- i. Fiber Link Performance Test – Each fiber span, (Primary POP to Carrier network (backhaul), POP-POP if multiple POP's, including each span to customer premise equipment POP-Cust Prem), as defined in the applicable design document(s), will require the following tests at a minimum:
  1. Link Optical Power
  2. Ping Test
  3. EtherBert
  4. Fiber OTDR and Power Meter Tests OLT to ONT Bi-directional

## 3. Conditional Acceptance Tests (System-Level):

- a. The Conditional Acceptance Tests (System-Level) verify that the performance of the system will meet the agreed service performance metrics. The acceptance procedures within this test also compile all required test results and acceptance documents into formal system acceptance packages.
- b. OPM and the Network Operator can optionally attend all Phase 4 testing activities. The Contractor must provide OWNER with 14 days' notice prior to commencing.
- c. Conditional Acceptance Testing (System-Level) must minimally include the following:
  - i. Network System Acceptance Package - This inspection based acceptance procedure verifies that all backbone fiber infrastructure, and documentation is in place as per the system design and testing requirements.
  - ii. Local Access Fiber System Acceptance Package - This inspection based acceptance procedure verifies that all Local fiber infrastructure and documentation is in place as per the system design and testing requirements.
  - iii. POP Acceptance Procedure – This inspection based acceptance procedure verifies that all POP infrastructure and documentation is in place as per the system design and testing requirements.

- iv. Transport Link System Acceptance Procedure – This inspection based acceptance procedure verifies that all Transport Links in the System have passed all applicable testing as per the testing requirements.
- v. Network System Acceptance Tests – These tests will verify network services are functional from the POP to a selected sample of specific end-points on the system (typically customer premise points). These tests measure Throughput, Latency, Jitter, and Packet Loss. The exact details of the Network System Acceptance Tests will be determined during the design phase. OPM will approve the proposed tests at their sole discretion.

## Appendix G: Cable and Wire Lacing Techniques

Figure A-1: Starting Stitch

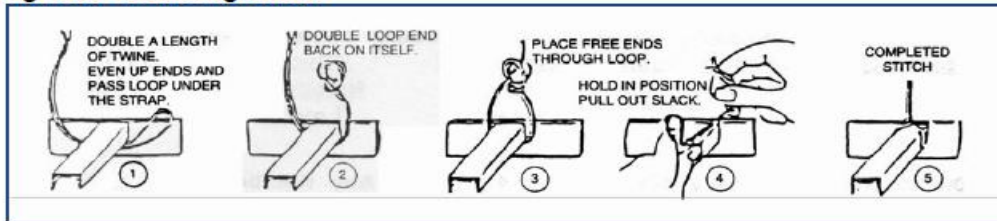
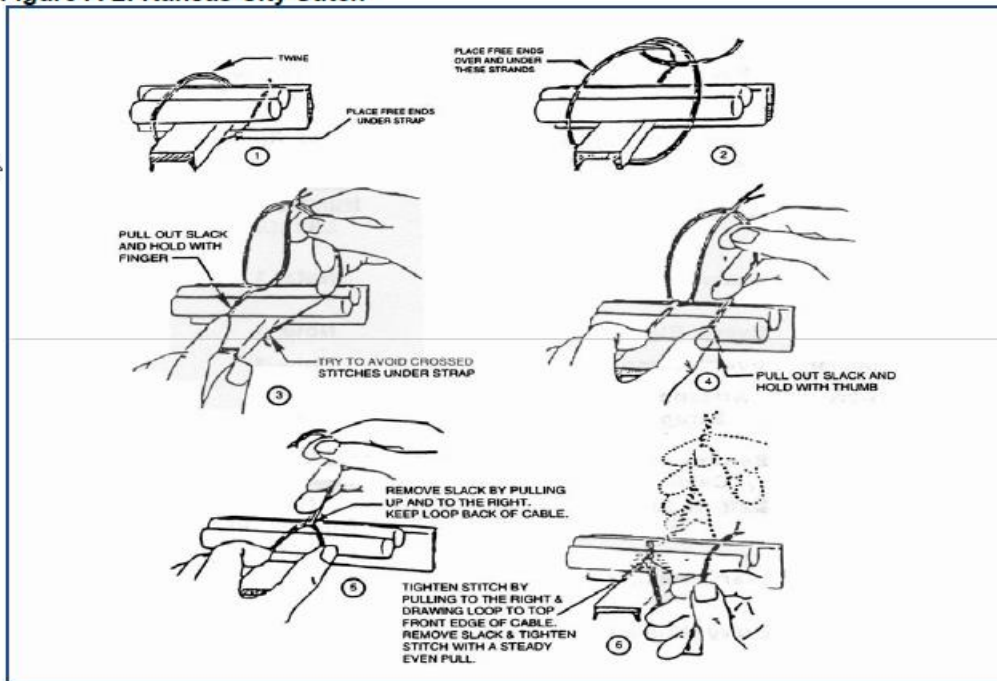
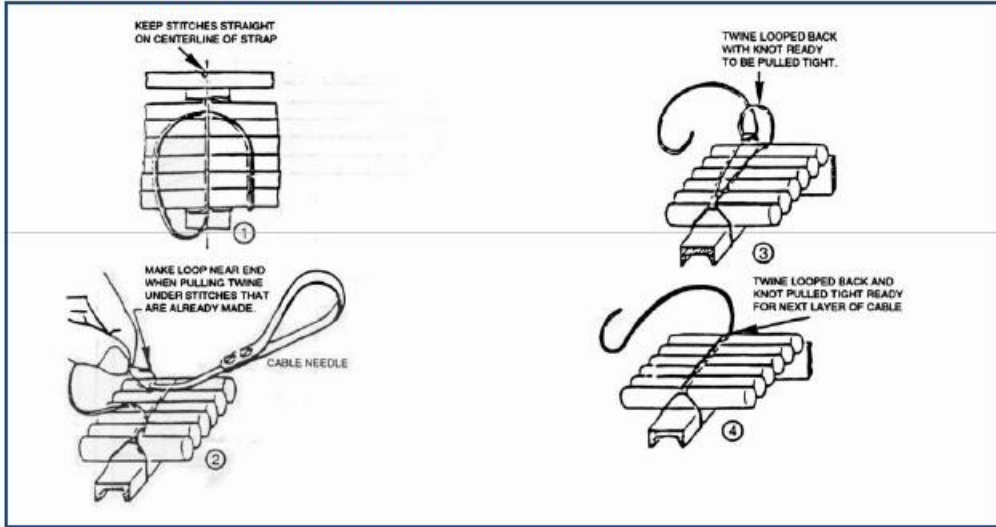


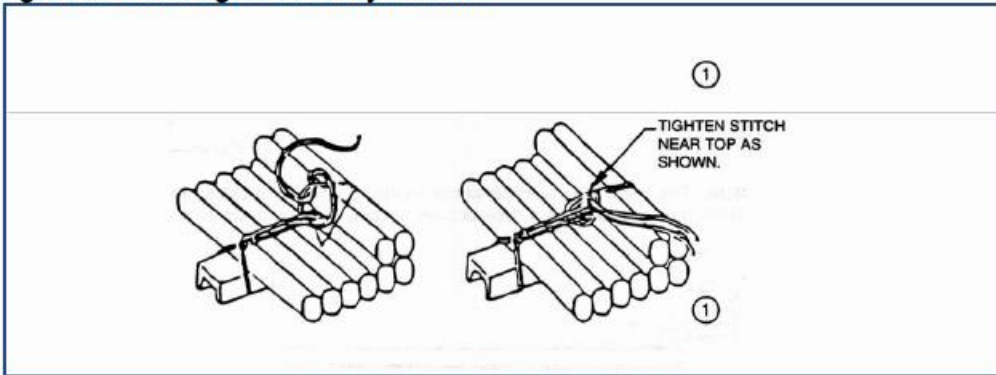
Figure A-2: Kansas City Stitch



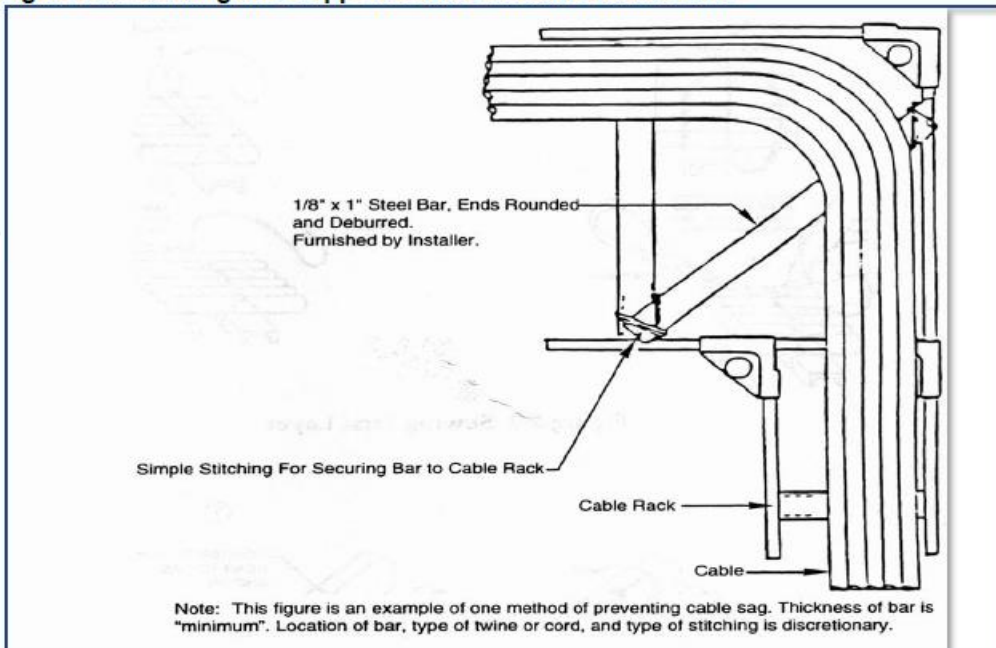
**Figure A-3: Sowing First Layer Stitch**



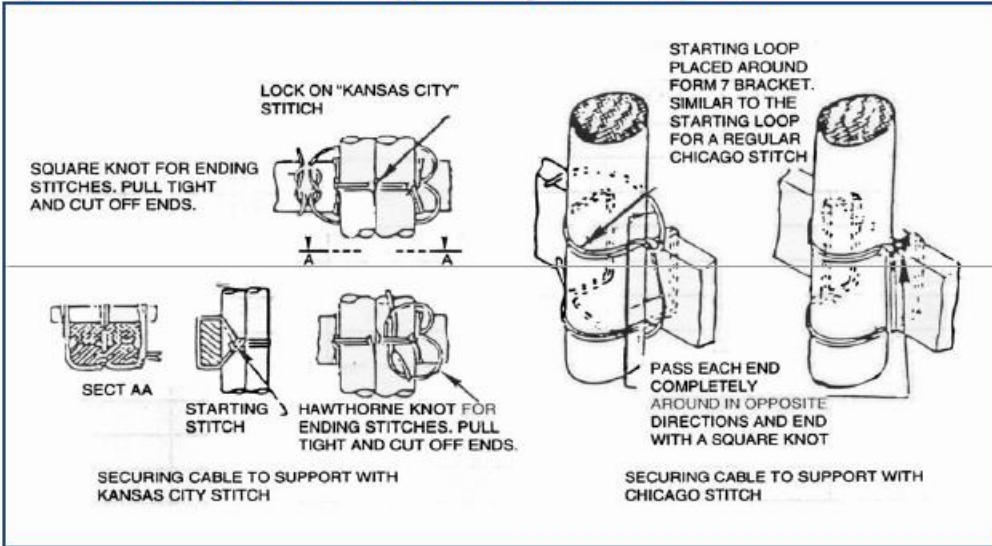
**Figure A-4: Sowing Second Layer Stitch**



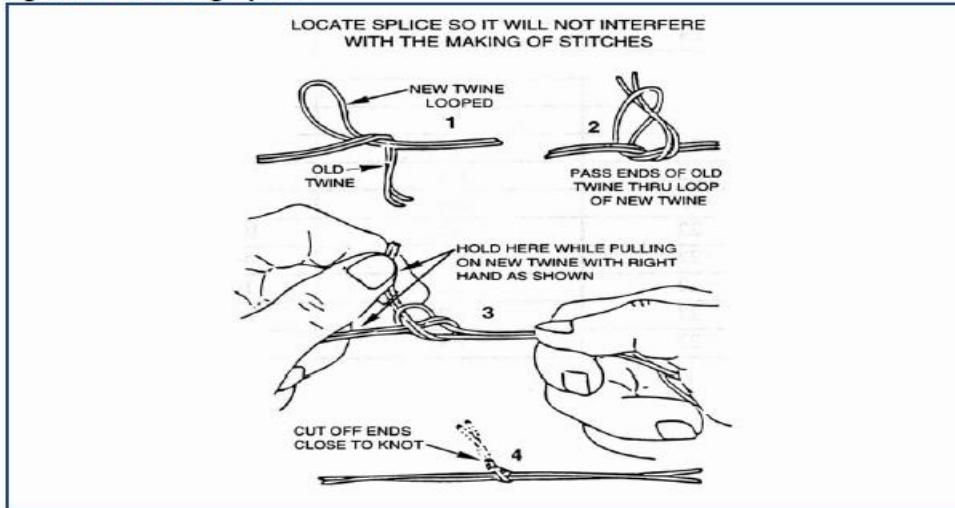
**Figure A-5: Sowing and Support Cables at Cable Rack Turns**



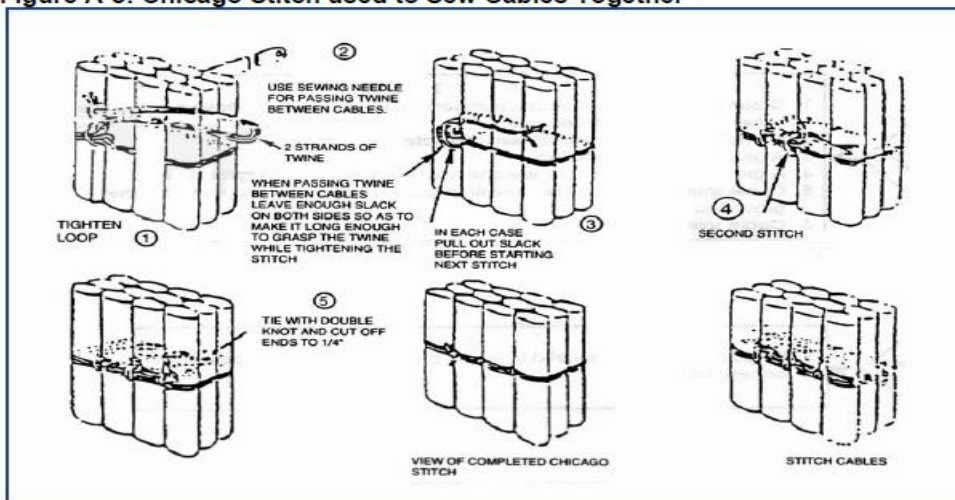
**Figure A-6: Securing Cable to Support Using Kansas City Stitch**



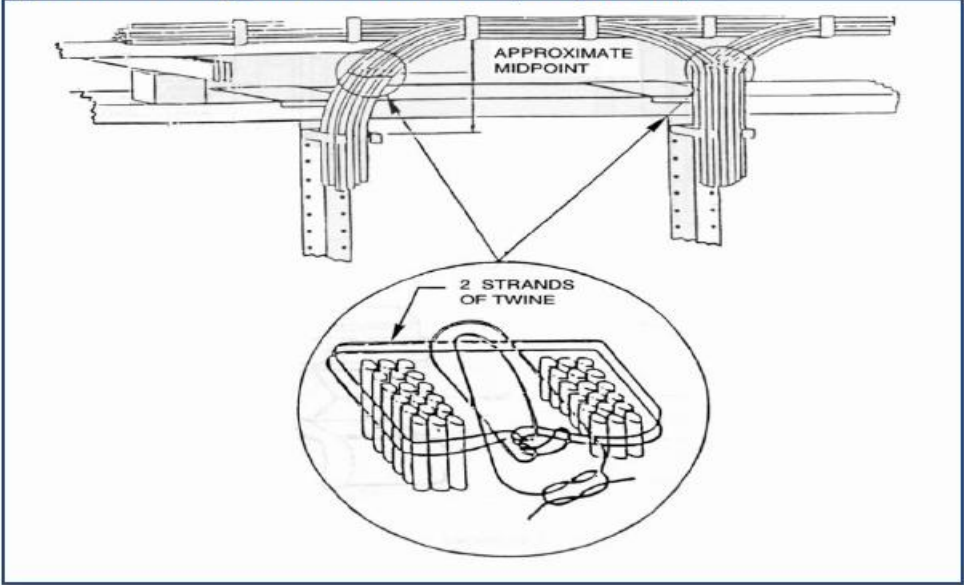
**Figure A-7: Lacing Splice**



**Figure A-8: Chicago Stitch used to Sew Cables Together**



**Figure A-9: Banding of Cables with 9-Wire (or equivalent)**



## Appendix H: Network Equipment Labeling and Naming Standards

### DC POWER & GROUNDING LABEL STANDARDS:

Labeller: Brother P-Touch Electronic Labeller, Model PT2300/2310 or approved equal.  
Label Type: Brother P-Touch Label Tape (TZ), 18mm, Black on White, Model TZ-241 or approved equal.  
Flag Marker Tie: Panduit "Pan-Ty" Flag Marker Tie PLF Series, Model PLF1MA or approved equal.

Labeller Settings: Font 1  
Size 6  
Width Medium  
Style Normal  
Alignment Centre  
Caps On

Standards: 4 line label standard (see examples below)  
5 digit equipment bay numbering mandatory (see examples below)  
"TO" and "FR" format mandatory. "TO" equals far end and "FR" equals near end (see examples below).  
Install labels approximately 50mm from the termination point.  
Install labels so text is right side up and clearly visible.  
Electronic labels to be affixed to matte finish side of Flag Marker Ties (not the gloss finish side).  
New electronic labels must never be affixed directly over old electronic labels.  
Damaged electronic labels must be replaced so all text is clearly legible.  
Electronic labels must be trimmed to fit surface of Flag Marker Ties.

#### *Example DC Power & Ground Labels*

*Example Device: Ciena OME 6500, Device Name: CLLIxxxxxx*

<i>-48V A-Side Feeder Conductor</i>	<i>+Rtn A-Side Feeder Conductor</i>	<i>PS Ground Conductor</i>
TO: CLLI xxxxxx FUSE PNL -48V BRKR Ax (20A) FR: CLLIXXXXXX PS1 A FEED -48V	TO: CLLIxxxxxx FUSE PNL +RTN BRKR Ax (20A) FR: CLLIXXXXXX PS1 A FEED +RTN	TO: 100.03 GND BAR FR: 100.03 CLLIXXXXXX PS1 GND
TO: CLLIXXXXXX PS1 A FEED -48V FR: CLLIxxxxxx FUSE PNL -48V BRKR Ax (20A)	TO: CLLIXXXXXX PS1 A FEED +RTN FR: CLLIxxxxxx FUSE PNL +RTN BRKR Bx (20A)	TO: 100.03 CLLIXXXXXX PS1 GND FR: 100.03 GND BAR
<i>-48V B-Side Feeder Conductor</i>	<i>+Rtn B-Side Feeder Conductor</i>	<i>Chassis Ground Conductor</i>
TO: CLLIxxxxxx FUSE PNL -48V BRKR Bx (20A) FR: CLLIXXXXXX PS1 B FEED -48V	TO: CLLIxxxxxx FUSE PNL +RTN BRKR Bx (20A) FR: CLLIXXXXXX PS1 B FEED +RTN	TO: 100.03 GND BAR FR: 100.03 CLLIXXXXXX CHASSIS GND
TO: CLLIXXXXXX PS1 B FEED -48V FR: CLLIxxxxxx FUSE PNL -48V BRKR Bx (20A)	TO: CLLIXXXXXX PS1 B FEED +RTN FR: CLLIxxxxxx FUSE PNL +RTN BRKR Bx (20A)	TO: 100.03 CLLIXXXXXX CHASSIS GND FR: 100.03 GND BAR

**COMMUNICATIONS CABLING LABEL STANDARDS:**

Labeller: Brother P-Touch Electronic Labeller, Model PT2300/2310 or approved equal.  
Label Type: Brother P-Touch Label Tape (TZ), 18mm, Black on White, Model TZ-241 or approved equal.  
Printable Label: Panduit "Ink Jet/Laser Printable Labels" p/n #LJSL7-Y3-1 or approved equal.

Labeller Settings: Font 1  
Size 6  
Width Medium  
Style Normal  
Alignment Centre  
Caps On

Standards: 4 line label standard (see examples below).  
5-digit equipment bay numbering mandatory (see examples below).  
"TO" and "FR" format mandatory. "TO" equals far end and "FR" equals near end (see examples below).  
Install labels approximately 50mm from the termination point.  
Install labels so text is right side up and clearly visible.  
Electronic label to be affixed (centered) onto white portion of Ink Jet/Laser Printable label (see examples below).  
Ink Jet/Laser Printable label to be neatly wrapped around (rolled tag) end of Communication cables.  
New electronic labels must never be affixed directly over old electronic labels.  
Damaged electronic labels must be replaced so all text is clearly legible.  
Electronic labels must be trimmed to fit white portion of Ink Jet/Laser Printable label.

***Copper and Fiber Patch Cable Example:***

***Ex. Switch located in Bay 100.04 connecting to Server port in Bay 100.03.***

***(Server port to Switch port)***

***Example Server port =SPFDMAATPPTSV001-(port) 1***

***Example Switch CLI + port = SPFDMAATPPSWT001-1-(port)1***

***Bay 100.04 Label Information***

TO: 100.03
SPFDMAATPPTSV001-1
FR: 100.04
SPFDMAATPPSWT001-1

***Bay 100.03 Label Information***

TO: 100.04
SPFDMAATPPSWT001-1
FR: 100.03
SPFDMAATPPTSV001-1



**ADDITIONAL LABEL STANDARDS:**

SIZES AND PLACEMENT OF CHARACTERS				
Equipment Type	Size	Font	Front (Top)	Rear (Bottom)
Frame, Bay, or Cabinet Base, End Guard/Shield, Main Bus and Ground Bars	5/8, 3/4, or 1 inch	60, 72 or 96	X	X
Frame, Bay, or Cabinet Upright / Cable Duct, Virtual CLEC Frame Designation	3/8, 5/8, or 3/4 inch	36, 60 or 72	X	X
Mounting Plates / Shelf / Panel / Unit	3/8 inch	36	X	X
Electronic Components / Connectors / Jack / Plug	1/8 or 3/16 inch	12 or 18		
Fuse / Breaker Panels and Individually-Mounted Fuse / Breaker Blocks	3/16 inch	18	X	See Note 3
Modular Fuse Blocks, Individual Fuse / Breaker on a Panel	1/8 inch	12	X	See Note 3
Fuse Record Book Covers, Detachable Fuse Assignment Record Sheets	3/8 inch	36	X	
Rectifiers, Converters, Inverters, etc. Group, Load, and Voltage	3/8, 5/8, 3/4 inch	36, 60 or 72	X	
Frame Blocks and Covers	3/8 inch	36	X	
Group / Frame / Equipment	3/8 inch	36	X	
Unit / Bank / Shelf / Etc.	3/16 inch	18	X	
Block Layout	1/8 inch	12	X	

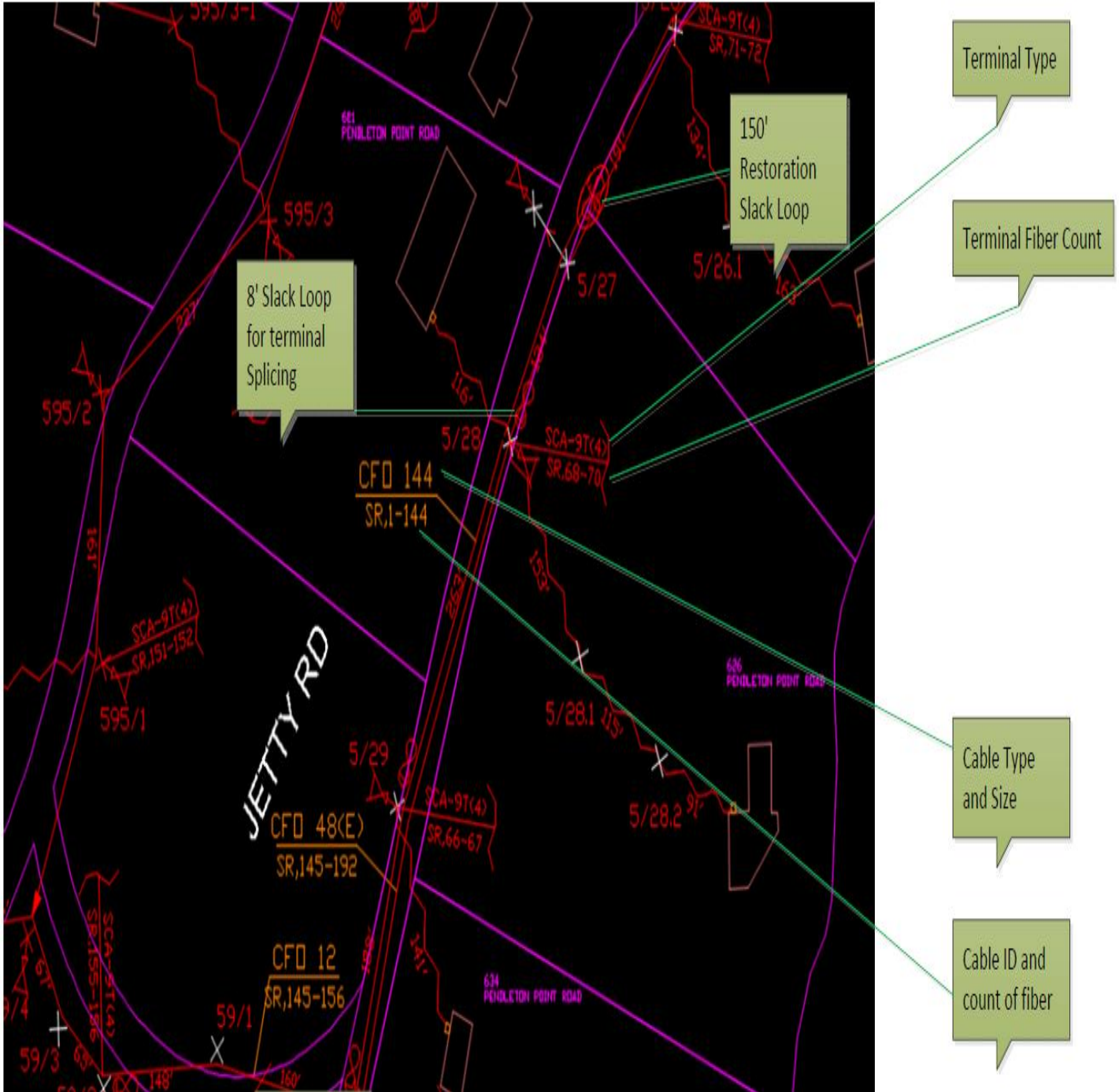
**Notes:**

1. Manufacturer's design or recommendations for their equipment shall take precedence over these recommendations.
2. Conversion table for "Inch" and "Font":

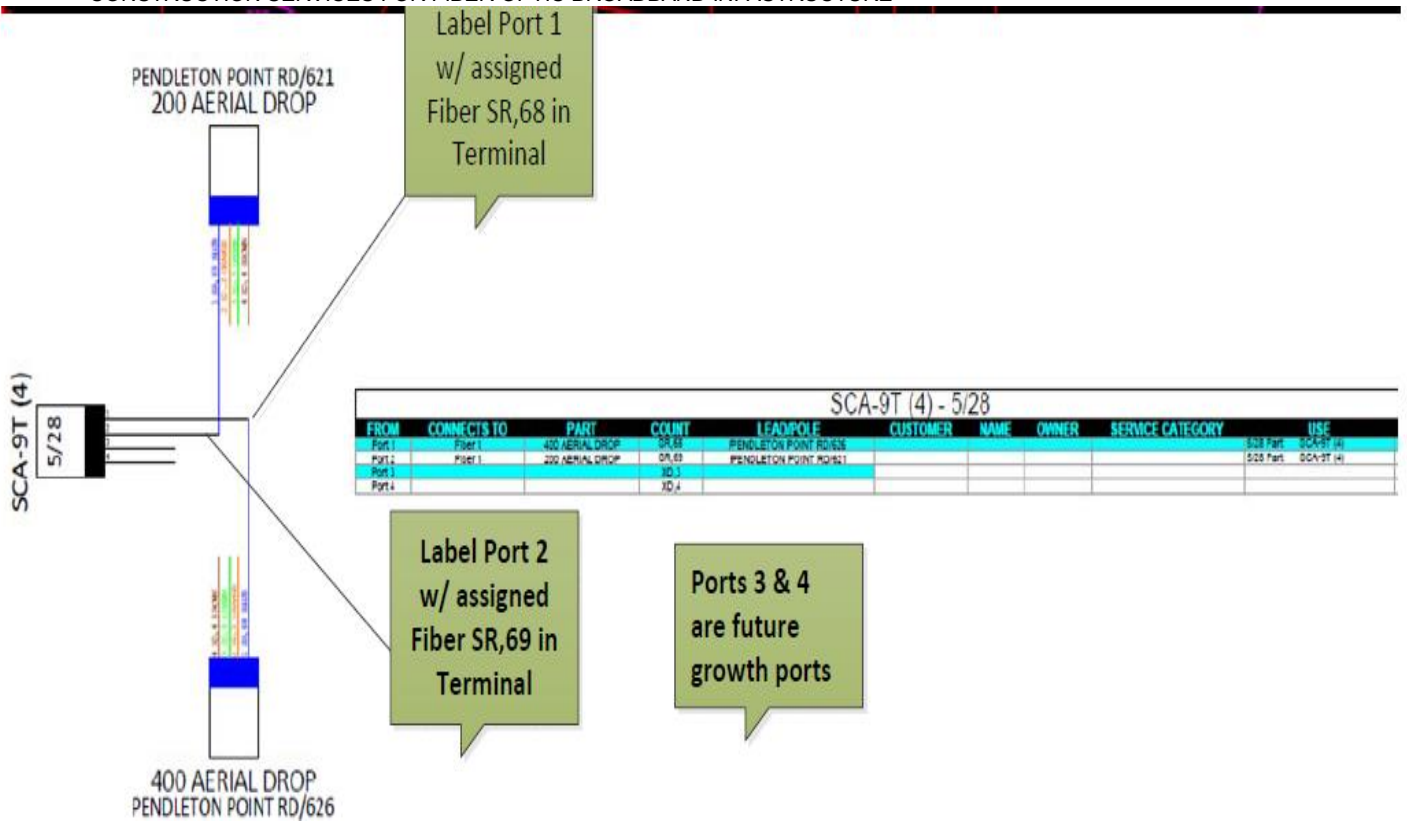
Inch	Font	Inch	Font
1/16	6	3/8	36
1/8	12	1/2	48
3/16	18	5/8	60
1/4	24	3/4	72
5/16	30	1	96

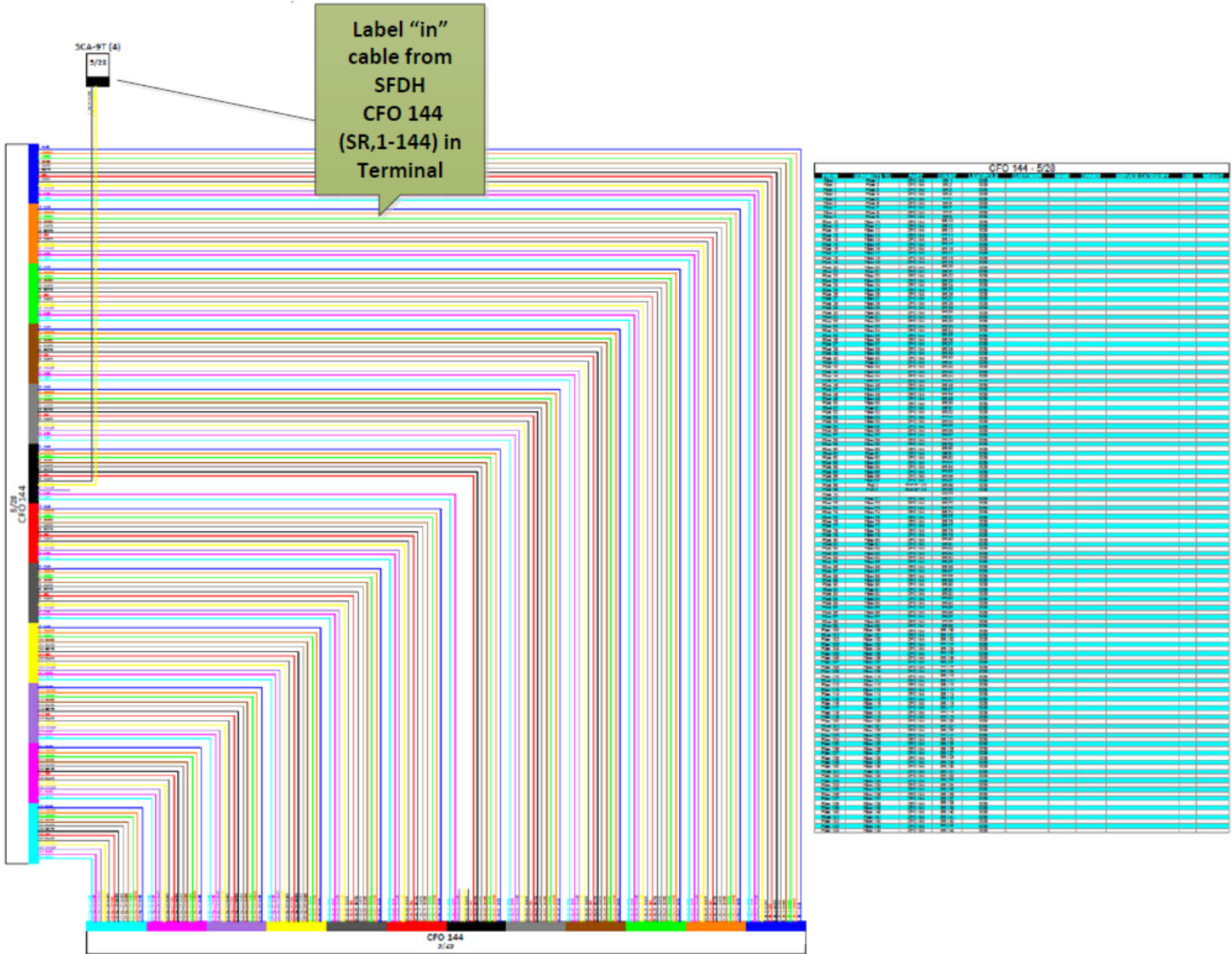
3. Circuit blocks shall be designated at a minimum of every other row. Punching designations shall be designated once at circuit # 1's location and at any change in circuit type. Circuit designations shall be aligned with the terminal they designate. Terminal designations shall be 1/8 inch or 12 points maximum and may be adjusted down in size to allow for additional information. All designations shall be legible.

## Appendix I: Outside Plant Labeling and Naming Standards



REQUEST FOR PROPOSALS  
RFP No. ISL-2017-01  
CONSTRUCTION SERVICES FOR FIBER OPTIC BROADBAND INFRASTRUCTURE





Appendix J: Acronyms and Definitions

REQUEST FOR PROPOSALS  
RFP No. ISL-2017-01  
CONSTRUCTION SERVICES FOR FIBER OPTIC BROADBAND INFRASTRUCTURE

Acronyms

AC	Alternating Current	MGB	Main Grounding Bus
ACEG	AC Equipment Ground	MOP	Method Of Procedure
AMP	Ampere	MT	Miscellaneous Trunk
APCL	Approved Product Classification List	NE	Network Element
AWG	American Wire Gauge	NEBS	Network Equipment Building Standards
BDCBB	Battery Distribution Control Breaker Board	NEC	National Electrical Code
BDFB	Battery Distribution Fuse Bay	NEMA	National Electrical Manufacturers' Association
CAR	Corrective Action Report	NFPA	National Fire Protection Association
CEC	Controlled Environment Cabinet	NMA	Network Monitoring and Analysis
CEF	Cable Entrance Facility	NROC	Network Reliability Operations Center
CEV	Controlled Environment Vault	OFNP	Optical Fiber Nonconductive Plenum
CFR	Code of Federal Regulations	OFNR	Optical Fiber Nonconductive Riser
CLEC	Competitive Local Exchange Carrier	OLM	Optical Loss Meter
CMGB	Collocator's Main Ground Bus	OPGP	Office Principle Ground Point
CN	Change Notice	OPGPB	Office Principle Ground Point Bus
CO	POI	OSHA	Occupational Safety & Health Administration
CO	POI Ground	OSP	Outside Plant
GRD		PB	Power Board/Bay
COE	POI Equipment	PDB	Power Distribution Board
COEIT	POI Equipment Installation Technician	PBD	Power Board/Bay Distribution
COEFM	POI Equipment Facility Management	PCB	Polychlorinated Biphenyl's
COGB	POI Grounding Bus bar	PCN	Product Change Notice
CSPEC	Common Systems Power & Space, Environment, POI	PDF	Power Distribution Frame
DC	Direct Current	PID	Part Identification
DCS	Digital Cross-Connection System	PPE	Personal Protective Equipment
DF	Distributing Frame	PVC	Polyvinyl Chloride
DNA	Do Not Assign	QP	G4S Procurement
DSX	Digital System Cross Connect	RC	Recording Code
DWP	Design Work Package	RMA	Returned Materials Authorization
EMT	Electrical Metallic Tubing	RR	Relay Rack
ESD	Electrostatic Discharge	SME	Subject Matter Expert
EPA	Environmental Protection Agency	SPCS	Stored Program Control System
FB	Fuse Bay	SPG	Single Point Ground
FDX	Fiber Distribution Cross Connect	SPGB	Signal Point Ground Bus Bay
FMT	Flexible Metallic Tubing	TEO	Telephone Equipment Order
GRD	Ground	UE	Universal Enclosure
HEPA	High Efficiency Particulate Arrester	UL	Underwriters Laboratory
HVAC	Heating, Ventilation and Air Conditioning	V	Volt
kcmil	Thousand Circular Mills	VRLA	Valve Regulated Lead Acid Battery
MGB	Main Grounding Bus		
MOP	Method Of Procedure		
MT	Miscellaneous Trunk		
NE	Network Element		

Definitions

**Fiber Optic Jumper:** A fiber optic conductor used to connect equipment and entrance cable on a distributing frame. Also, a fiber optic patch cable or conductor used to establish a circuit, often temporarily, for testing or diagnostics.

**Fiber Optic Patch Cord:** Single fiber cables with connectors on each end used to join communication circuits at a cross-connect point, Fiber Distribution Frame (FDF) or Next Generation Frame (NGF).

**Tinned Wire:** Copper wire that has been coated during manufacture with a layer of tin or solder to prevent corrosion and simplify soldering of connections.

REQUEST FOR PROPOSALS  
RFP No. ISL-2017-01  
CONSTRUCTION SERVICES FOR FIBER OPTIC BROADBAND INFRASTRUCTURE

**Commissioning:** Process by which equipment, facility, or plant (which is installed, or is complete or near completion) is tested to verify if it functions according to its design objectives or specifications. After installation is finished, the equipment is powered up and tested in a standalone environment. Also, the latest software version and settings are confirmed and loaded into the equipment configuration.

**Integration:** Is the act of bringing together smaller components into a single system and tested to confirm the system functions as one. After the equipment is commissioned, the network elements need to be connected to the network, integrated and tested to become a functional part of the network.