REQUIREMENTS FOR ELECTRIC SERVICE

City of Loveland
Electric & Communication

EFFECTIVE DATE: January 1, 2020

City of Loveland
Water and Power
200 N. Wilson Ave.
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Table of Contents

Requirements for Electric Service .............................................................................. 15
Important Contacts ..................................................................................................... 16
Important Documents ................................................................................................. 17
Definitions & Acronyms .............................................................................................. 18

1.1 General Requirements ....................................................................................... 24
  a. Call for Locates .................................................................................................. 24
  b. Dangers & Penalties for Digging into Buried Electrical Installations .................. 24
  c. Illegal Modifications & Tampering..................................................................... 24
  d. Metered Electrical Power .................................................................................. 24
  e. Mounting Customer-Owned Equipment ............................................................... 24
  f. Unmetered Yard Lights/ Free Porch Light Program ............................................. 24
  g. Disconnect Timeframe ...................................................................................... 24
  h. Permits & Meter Inspections ............................................................................ 25
  i. Warehouse Hours .............................................................................................. 25
  j. Ownership of Electrical Distribution System ..................................................... 25

1.2 Overhead and Underground Facilities ................................................................. 25
  a. New Services Underground .............................................................................. 25
  b. Convert Overhead Services to Underground ...................................................... 25

1.3 Electrical Service Voltage Standards ................................................................. 25
  a. Standard Services ............................................................................................. 25
  b. Standard Voltage Classification ....................................................................... 25
  c. Nominal Secondary Voltages .......................................................................... 25

1.4 Service Quality .................................................................................................... 26
  a. Voltage Level ................................................................................................... 26
  b. Power Irregularities & Interruptions ................................................................. 26

1.5 Motors and Three-Phase Equipment .................................................................... 26
  a. Air Conditioners & Heat Pumps Requiring Soft Starts ..................................... 26
  b. Motors Requiring Soft Starts ......................................................................... 26
  c. Motor Start Analysis Requirements ................................................................ 26
d. Motor Protection Responsibility .......................................................... 26

SECTION 2 - TEMPORARY OVERHEAD & UNDERGROUND ............................. 27

2.1 Temporary Construction Services ....................................................... 28
   a. Temporary Construction Power .......................................................... 28
   b. Address Posting Requirements ......................................................... 28
   c. Location Requirements ................................................................. 28
   d. Conductor Requirements for Underground Temporary Power .............. 28
   e. Temporary Pole & Meter Equipment Requirements ............................ 28
   f. NEC Requirements ........................................................................... 28

2.2 Residential Development Construction Power ........................................ 28
   a. Applying for Residential Development Construction Temporary Power ... 28
   b. Building Permits & Fees .................................................................... 29
   c. Inspection & Energizing ..................................................................... 29
   d. Utility Locates ................................................................................... 29
   e. Temporary Meter Poles ...................................................................... 29
   f. Standard Service Voltage ................................................................... 29
   g. Service Connection Timeframe ......................................................... 29
   h. Contractor Installed Equipment .......................................................... 29
   i. Approved Meter Sockets ..................................................................... 29
   j. Accessible Meter Locations ............................................................... 29
   k. Meter Ground Rods ........................................................................... 29

2.3 Commercial Development Construction Power ........................................ 29
   a. Applying for Commercial Development Construction Temporary Power .... 30
   b. Inspection & Energizing ..................................................................... 30
   c. Utility Locates ................................................................................... 30
   d. Standard Services ............................................................................. 30
   e. Meter Socket Requirements ............................................................... 30
   f. No Meters on Utility Poles ................................................................. 30
   g. Service Connection Timeframe ......................................................... 30
   h. Developer/Contractor Installed Equipment ........................................ 31
   i. Approved Meter Sockets ..................................................................... 31
   j. Meter Location Approvals .................................................................. 31
   k. Accessible Meter Locations ............................................................... 31
   l. Meter Ground Rods ........................................................................... 31
3.1 Residential Service – General ................................................................. 35
   a. All New Residential and Upgraded services shall be underground ...................... 35
   b. Demarcation Point .................................................................................. 35
   c. Additional Fees May Apply ................................................................... 35
   d. Easement Requirements ........................................................................ 35
   e. Utility Locates ....................................................................................... 35
   f. Mark Lot Corners ................................................................................... 35
   g. Additional Meters on a Single Residential Lot ........................................ 35
   h. Meter Socket Requirements ................................................................ 35
   i. Accessible Meter & Service Entrance ................................................... 36
   j. Construction Standards ........................................................................ 36
   k. Service Entrance Standards ................................................................. 36
   l. Keep Area around Service Clear ............................................................. 36
   m. Violations ............................................................................................... 36
   n. Grounding Method ................................................................................ 36
   o. Customer Installed Item Requirements .................................................. 36
   p. Access Restrictions to City Equipment .................................................... 36
   q. 600V or less Trench Requirements ......................................................... 36
   r. Conduit Requirements .......................................................................... 36
   s. Slip Coupling Riser Requirements .......................................................... 37
   t. Warning Tape ........................................................................................ 37
   u. Backfill Requirements .......................................................................... 37
   v. Damage Prevention ................................................................................ 37

3.2 New Residential Service with Power at the Lot Line ........................................ 37
   a. Applying for New Residential Service with Power at the Lot Line ............ 37
   b. Building Permits & Fees ....................................................................... 37
   c. Inspection & Energizing ......................................................................... 37
   d. General Requirements ......................................................................... 37

3.3 New Residential Service without Power at the Lot Line .................................. 38
   a. Applying for New Residential Service without Power to the Lot Line ......... 38
   b. Building Permits & Fees ...................................................................... 38
   c. Inspection & Energizing ....................................................................... 38
   d. General Requirements ......................................................................... 38
3.4 Residential Underground Service Upgrade ................................................................. 38
   a. Applying for Residential Service Upgrade ......................................................... 38
   b. Building Permits & Fees ....................................................................................... 39
   c. Service Disconnects ............................................................................................... 39
   d. Inspection & Energizing ......................................................................................... 39
   e. General Requirements ........................................................................................... 39

3.5 Residential Overhead Service Upgrade .................................................................... 39
   a. Applying for Residential Overhead Service Upgrade ........................................... 39
   b. Building Permits & Fees ....................................................................................... 40
   c. Service Disconnects ............................................................................................... 40
   d. Inspection & Energizing ......................................................................................... 40
   e. Demarcation Point ................................................................................................. 40
   f. Attachment Point Requirements .......................................................................... 40
   g. Connection Point Requirements .......................................................................... 40
   h. Attachment Requirements .................................................................................... 40
   i. General Requirements ........................................................................................... 41

3.6 Additional Service Added .......................................................................................... 41
   a. Applying for Additional Service .......................................................................... 41
   b. Building Permits & Fees ....................................................................................... 41
   c. Inspection & Energizing ......................................................................................... 41
   d. Additional Meters on a Single Residential Lot ...................................................... 41
   e. General Requirements ........................................................................................... 41

3.7 Mobile, Cottage, or Tiny Home Communities .......................................................... 41
   a. General ................................................................................................................ 41
   b. Lots Owned by Mobile Home Parks-Upgrades ...................................................... 42
   c. Lots Owned Individually-Upgrades ..................................................................... 42

3.8 Electrical Substructure in New Subdivisions ............................................................ 42
   a. Electrical Design, Fees & Contractor Orientation ............................................... 42
   b. Easement Area Requirements .............................................................................. 42
   c. Pre-Construction Meeting .................................................................................... 42
   d. Trenching & Foundation Requirements ............................................................... 42
   e. Installation Requirements ..................................................................................... 42

SECTION 4 - COMMERCIAL & INDUSTRIAL .................................................................... 51

4.1 New or Upgraded Commercial & Industrial Service - General ............................... 52
5.1  Trenching - General ................................. 58
   a. Minimum Separation from Other Utilities ..... 58
   b. Minimum Separation for Multiple Conduits 58
   c. Trench Specifications .......................... 58
   d. Excavation Requirements ........................ 58
   e. Trench Variances ................................ 58
   f. Trench Width .................................... 58
   g. Trench Bottoms .................................. 58
   h. Trench Cover .................................... 58
   i. Backfill Materials ............................... 58
   j. Trench Backfill .................................. 59
   k. Compaction Methods ............................ 59

4.2  Commercial & Industrial Services – Underground ........................................ 53
   a. City Work Paid by Customer .................... 53
   b. City Supplied Subsurface Structures .......... 53
   c. Customer Supplied Items ........................ 53
   d. Demarcation Point ............................... 53
   e. Underground Service Installations ............ 53

4.3  Existing Commercial & Industrial Services – Overhead .................................. 53
   a. Demarcation Point ............................... 53
   b. Attachment Point Requirements ............... 54
   c. Attachment Requirements ........................ 54
   d. Keep Area around Service Clear ............... 54

SECTION 5 – TRENCHING & BORING ................................................................. 57

   a. All New or Upgraded Commercial and Industrial Services shall be underground ............... 52
   b. Applying for New or Upgraded Commercial & Industrial Service ............................... 52
   c. Easement Requirements .......................... 52
   d. Utility Locates .................................... 52
   e. City Furnished Materials & Installation Standards .................................................... 52
   f. Cable Tray ........................................ 52
   g. Wiring Standards .................................. 52
   h. Final Inspection Prior to Meter Installation ......................................................... 53
   i. Pre-Construction Meeting .................................. 53
   j. Meter Pedestal Installations ..................... 53
l. Compaction Tests .........................................................................................................59
m. Underground Equipment Inspection .........................................................................59
n. Tracer Wire ................................................................................................................59

5.2 Boring – General .....................................................................................................59
   a. Description ............................................................................................................59
   b. Boring Fluid (Mud) System ...................................................................................59
c. Equipment ...............................................................................................................60
d. Record Keeping: As-Builts ......................................................................................60
e. Bore Inspection .........................................................................................................60

5.3 Structural Fill, Flowable Fill and Concrete Duct Encasement ..................................60
   a. Structural Fill ........................................................................................................60
   b. Areas Requiring Flowable Fill ..............................................................................61
c. Flow Fill ..................................................................................................................61
d. Concrete Duct Encasement ......................................................................................61

5.4 Cable Handling .......................................................................................................61
   a. Unloading Cable Requirements ................................................................ ..........61
   b. No Dropping Cable Reels .....................................................................................61
c. Cable Reel Storage Requirements .........................................................................62
d. Rolling Cable Reel Requirements ..........................................................................62
e. Seal Cable Ends ........................................................................................................62
f. Cable-in-Conduit Length for Vaults .........................................................................62

SECTION 6 - METERS AND METER CONNECTIONS ..................................................75

6.1 Metering Requirements – General ........................................................................76
   a. Meter Installation Requirements .........................................................................76
   b. Electric Service Delivered to a Single Point ...........................................................76
c. Upgrading Equipment/Service to an Existing Building .........................................76
d. Building Use Changes ............................................................................................77
e. Compromised or Unauthorized Changes to Meter/Meter Equipment .....................77
f. Electronic Load Data Collection ..............................................................................77
g. Installation of Emergency or Back-up Generation ..................................................77
h. City to Install Locks & Seals ...................................................................................77
i. City to Cut Locks & Seals or Remove Meters ...........................................................77
j. No Jumpered Sockets ..............................................................................................77
k. Replace Damaged Meter Socket Lids .......................................................................77
6.2 Meter & Associated Equipment Locations

a. Meter Location Approval .......................................................... 79
b. Prohibited Meter Locations ...................................................... 79
c. Access to Meter Equipment Required by City ............................ 79
d. Keep Meter Access Clear .......................................................... 79
e. Sloped/Uneven Final Grades around Meter ................................. 79
f. Parking Bollards (Posts) ............................................................. 79
g. Protective Enclosures .............................................................. 79
h. Repeated Damage to Metering Equipment ............................... 79

6.3 Meter Equipment Mounting ..................................................... 79

a. Who Installs & Supplies Metering Equipment ............................ 79
b. Meter Mounting ..................................................................... 80
c. Prohibited Meter Mounting Locations ..................................... 80
d. Mounting Heights ................................................................. 80
e. CT Mounting Requirements ..................................................... 80
f. Service Conduit Requirements ................................................ 80
g. Metering Clearances ............................................................... 80

6.4 Sequence of Meter, Service Entrance and Customer Equipment Connections ......................................................... 80

a. Cold Sequencing .................................................................. 80
b. No Customer Equipment Ahead of Electric Metering ..................... 81
c. No Separately Derived Power Source Ahead of City Metering ......... 81
d. No Junction Boxes at Meter Sockets or CT Cabinets ..................... 81

6.5 Residential (Single Family Homes or Duplexes) ...................... 81

a. Approved Meter Sockets .......................................................... 81
b. Demarcation Point .................................................................. 81
c. Replacing Meter Pedestals ........................................................ 81
d. Multi-Family Dwellings with Three or More Meters .................... 81
e. Residential Services Greater than 400 Amps .............................. 81

6.6 Mobile Home Parks ................................................................. 81

a. Service Wire Source & Ownership ........................................... 81
6.7 Commercial and Industrial (Includes Multi-Family Housing with Three or More Dwellings & Residential Services Greater than 400 Amps).............................................................. 82
a. 277/480 Volts up to 400 Amp Services ........................................................................ 82
b. Self-Contained Meters ................................................................................................ 82
c. Single-Phase Three-Wire, 240 Volts, 400 Amp Services .................................................. 82
d. Three-Phase 120/208 volt Four-Wire Services Greater than 400 Amps & Single-Phase Services Greater than 400 Amps ................................................................. 82
e. Address Posting at Entrance Doors & Meter Sockets ...................................................... 82
f. Address Labeling of Meters .......................................................................................... 82
g. Temporary Meter Design for Services Greater than 200 Amps ............................................ 83
h. Sub-Metering .............................................................................................................. 83
i. Demarcation Point ....................................................................................................... 83
j. Site/Parking Lot Lighting .............................................................................................. 83

6.8 Multiple Metering .................................................................................................. 83
a. Address Posting at Entrance Doors & Meter Sockets ...................................................... 83
b. Address Labeling of Meters .......................................................................................... 83
c. Liability for Mis-Wiring or Incorrect Labeling ............................................................... 84
d. House Meter for Multiple Tenant Buildings .................................................................. 84
e. Multi-Occupancy Buildings with Individual Tenant Meters ............................................ 84
f. Meter Equipment Approval ............................................................................................. 84
g. 120/208 Volts Single-Phase Multiple Metering Equipment .............................................. 84

6.9 Transformer Rated Metering (CTs & PTs) ................................................................ 84
a. All single-phase and three-phase Services Greater than 400 Amps ........................................ 84
b. 277/480 Volt Services Greater than 400 Amps ................................................................ 84
c. Approved CT Cabinets .................................................................................................... 84
d. Main Disconnects or Combined Service Disconnects ......................................................... 84
e. Prohibited Installation Locations .................................................................................... 85
f. CT-Rated Metering Request Submittals ............................................................................ 85
g. Switchgear CT Compartment Requirements .................................................................. 85
h. Wall-Mounted Cabinet Requirements ............................................................................ 85
i. Pad-Mounted Cabinet Approvals .................................................................................... 85
j. No Pull Boxes/Junction Boxes at Meter Sockets or CT Cabinets ......................................... 85
k. Conduit Requirements

l. Ground Bonds

m. City Furnished Materials & City Installations

6.10 Primary Metering

a. Primary Metering Installations

b. Vaults Under Primary Metering Cabinets

c. Meter Sockets & Meter Installations

d. Overhead Primary Metering

e. Primary Meter Testing & Certification

f. Replacing Primary Metering Equipment

6.11 Load Pulse Outputs

a. Load Pulse Outputs

b. Pulse Output Meters

c. Energizing Requirements

d. Energy Management System Configuration

SECTION 7 - METER SOCKET CONNECTIONS

SECTION 8 - CLEARANCES

8.1 General Clearances

a. Pad-Mounted Equipment Clearances

b. Damage Due to Inadequate Access

c. Parking Bollards (Posts)

d. Clearances from Windows & Doors

8.2 Overhead Clearances

a. Overhead Clearance Table

8.3 Underground Clearances

a. Underground Clearances Drawing

b. Pad-Mounted Equipment Clearances

c. Permanent Structures Not Permitted Above Underground Conductors

8.4 Swimming Pools or Hot Tubs/Spas

a. Swimming Pool or Hot Tubs/Spas Clearances

8.5 Flammable Gases or Liquids

a. Tanks of Flammable Gases or Liquids Clearances

SECTION 9 - INTERCONNECTION REQUIREMENTS FOR GENERATING FACILITIES NO LARGER THAN 2 MVA

9.1 Introduction
9.2 General Requirements for Interconnection
   a. Application................................................................. 112
   b. System Sizing .......................................................... 112
   b. Permits ........................................................................ 112
   c. Authorization .............................................................. 113
   d. Codes and Standards ................................................... 113
   e. Isolation Transformer .................................................... 114
   f. Fault-Interrupting Devices (Fuses and Circuit Breakers) .... 115
   g. Manual Disconnect Switch ............................................. 116
   h. Rapid Shutdown for PV Systems ..................................... 117
   i. Protective Equipment .................................................... 117
   j. Safety, Reliability and Quality of Service ....................... 119
   k. Isolated Operation ....................................................... 119
   l. Facility System Disturbances .......................................... 120
   m. Utility System Disturbances .......................................... 120
   n. Back-feed to the Utility System ..................................... 120
   o. Power Quality ............................................................. 120
   p. Grounding .................................................................. 121

9.3 Emergency Generator Requirements ........................................ 121
   a. Break-Before-Make (Open Transition) ......................... 121
   b. Make-Before-Break (Closed Transition) ......................... 122

9.4 System Impact Study .......................................................... 123
   a. System Impact Study .................................................... 124

9.5 Requirements for Interconnection ........................................... 124
   a. Line Protection ............................................................ 124
   b. Generator/Intertie Protection and Control ...................... 125
   c. Circuit Breaker/Recloser (Device 52) ............................. 127
   d. Phase Overcurrent (Device 50/51) ................................. 127
   e. Phase Overcurrent Relay with Voltage Restraint/Voltage Control (Device 51V) ........................................... 127
   f. Under/Overvoltage Relay (Device 27/59) ....................... 127
   g. Over/Under Frequency Relay (Device 810/U) .................. 128
   h. Synchronizing (Device 15/25) and Synch-Check (Device 25) ................................................................. 129
   i. Undervoltage Check (Device 27R) ................................ 130
j. Current Unbalance (Device 46) .................................................................................................................. 130
k. Voltage Unbalance (Device 47) .................................................................................................................. 131
l. Ground Fault Sensing Scheme (Device 51G) ............................................................................................... 131
m. Phase Directional Overcurrent (Device 67) ............................................................................................... 131
n. Direct Transfer Trip (DTT) ......................................................................................................................... 131
o. Recloser Operation and Reclose Blocking ................................................................................................. 132
p. Inverters Capable of Stand-Alone Operation and Photovoltaics (PV) ....................................................... 132

9.6 Metering ................................................................................................................................................. 133
    a. Signage ..................................................................................................................................................... 133

9.7 Commissioning Test ................................................................................................................................. 133
    a. Commissioning Testing .............................................................................................................................. 133
    b. Scheduled Testing .................................................................................................................................... 134
    c. Testing Qualifications ............................................................................................................................... 134

9.8 Generation and Power Conversion Technologies ....................................................................................... 134
    a. Synchronous Generators .......................................................................................................................... 134
    b. Asynchronous (Induction) Generators ....................................................................................................... 135
    c. Inverters ................................................................................................................................................... 136

9.9 Example Protection Diagrams .................................................................................................................... 136

9.10 Example Fault Considerations .................................................................................................................. 145

9.11 Interconnection Standard References ..................................................................................................... 147

REVISION LOG ............................................................................................................................................... 152
## DRAWING TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>No.</th>
<th>Section &amp; Drawing Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Section 2 - Temporary Overhead &amp; Underground</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.1</td>
<td>Temporary Meter Installation Overhead</td>
<td>32</td>
</tr>
<tr>
<td>2.2</td>
<td>Temporary Meter Installation Underground</td>
<td>33</td>
</tr>
<tr>
<td><strong>Section 3 – Residential</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.1</td>
<td>Residential Overhead Service</td>
<td>43</td>
</tr>
<tr>
<td>3.2</td>
<td>Handhole Locations</td>
<td>44</td>
</tr>
<tr>
<td>3.3</td>
<td>Transformer Pad Locations</td>
<td>45</td>
</tr>
<tr>
<td>3.4</td>
<td>Single-phase Transformer For Temporary Service</td>
<td>46</td>
</tr>
<tr>
<td>3.5</td>
<td>Single-phase Transformer Pad Box</td>
<td>47</td>
</tr>
<tr>
<td>3.6</td>
<td>Single-phase Sectionalizing Cabinet</td>
<td>48</td>
</tr>
<tr>
<td>3.7</td>
<td>Residential Underground Meter and Service Locations</td>
<td>49</td>
</tr>
<tr>
<td>3.8</td>
<td>Residential 400amp Services</td>
<td>50</td>
</tr>
<tr>
<td><strong>Section 4 - Commercial &amp; Industrial</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.1</td>
<td>Three-Phase Transformer Installation</td>
<td>55</td>
</tr>
<tr>
<td>4.2</td>
<td>Secondary Handholes</td>
<td>56</td>
</tr>
<tr>
<td><strong>Section 5 – Trenching &amp; Boring</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.1</td>
<td>Trench Details</td>
<td>63</td>
</tr>
<tr>
<td>5.2</td>
<td>Three-Phase Sectionalizing Cabinet</td>
<td>64</td>
</tr>
<tr>
<td>5.3</td>
<td>Vault Details</td>
<td>65</td>
</tr>
<tr>
<td>5.4</td>
<td>Vault Details - Conduit Detail</td>
<td>66</td>
</tr>
<tr>
<td>5.5</td>
<td>5’x5’ Vault Details</td>
<td>67</td>
</tr>
<tr>
<td>5.6</td>
<td>5’x8’ Vault Details</td>
<td>68</td>
</tr>
<tr>
<td>5.7</td>
<td>7’x13’ SWG Vault Details</td>
<td>69</td>
</tr>
<tr>
<td>5.8</td>
<td>7’x13’ Hatch Only Vault Details</td>
<td>70</td>
</tr>
<tr>
<td>5.9</td>
<td>8’x19’ SWG Vault Details</td>
<td>71</td>
</tr>
<tr>
<td>5.10</td>
<td>8’x19’ Lid Configurations</td>
<td>72</td>
</tr>
<tr>
<td>5.11</td>
<td>Concrete Base for Streetlights</td>
<td>73</td>
</tr>
<tr>
<td>5.12</td>
<td>Utility Crossing</td>
<td>74</td>
</tr>
<tr>
<td><strong>Section 6 - Meters &amp; Meter Connections</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.1</td>
<td>Meter Clearances</td>
<td>89</td>
</tr>
<tr>
<td>6.2</td>
<td>Underground Multiple Meter</td>
<td>90</td>
</tr>
<tr>
<td>6.3</td>
<td>Manufactured Meter Pedestal</td>
<td>91</td>
</tr>
<tr>
<td>6.4</td>
<td>H-Frame Meter Stand</td>
<td>92</td>
</tr>
<tr>
<td>6.5</td>
<td>CT Metering</td>
<td>93</td>
</tr>
<tr>
<td>6.6</td>
<td>CT Metering Cabinet</td>
<td>94</td>
</tr>
<tr>
<td>6.7</td>
<td>Load Control Pulse Output</td>
<td>95</td>
</tr>
<tr>
<td><strong>Section 7 - Meter Socket Connections</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7.1</td>
<td>Meter Socket Terminal Arrangement</td>
<td>97</td>
</tr>
<tr>
<td>7.2</td>
<td>Single-phase 120/240 Volts Three-Wire</td>
<td>98</td>
</tr>
<tr>
<td>7.3</td>
<td>Three-Wire 120/208 Volts WYE Two Stator Meter &amp; Five Terminal Socket</td>
<td>99</td>
</tr>
<tr>
<td>7.4</td>
<td>Three-Phase Four-Wire 120/240 Volts Delta Self Contained Two Stator Meter</td>
<td>100</td>
</tr>
<tr>
<td>7.5</td>
<td>Three-Phase Four-Wire WYE 3-Stator 120/208, 277/480 Volt Meter</td>
<td>101</td>
</tr>
</tbody>
</table>
### Section 8 – Clearances

<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>8.1</td>
<td>Pad-Mounted Equipment Clearances</td>
<td>106</td>
</tr>
<tr>
<td>8.2</td>
<td>Minimum Clearance Requirements</td>
<td>107</td>
</tr>
<tr>
<td>8.3</td>
<td>Swimming Pool or Hot Tub/Spa Clearances</td>
<td>108</td>
</tr>
<tr>
<td>8.4</td>
<td>Clearances for Building Openings</td>
<td>109</td>
</tr>
<tr>
<td>8.5</td>
<td>Clearances from Flammable Gas or Liquid</td>
<td>110</td>
</tr>
</tbody>
</table>
**Requirements for Electric Service**

**Intent:**
This booklet provides information to power customers concerning conditions for service and standards for construction of the customer’s electric service. Standards contained within this publication are set by the NESC, NEC, and applicable City municipal codes and must be strictly followed.

Customers must demonstrate compliance with all applicable provisions within these Requirements for Electric Services before receiving electrical service from the City of Loveland Water and Power, unless exempted in writing by the Director of Water and Power or their designee. Existing installations which fail to meet requirements for clearance and/or access to City equipment may be subject to additional fees and/or disconnection of electric service. Requirements contained herein are for reference and guideline purposes, they are not intended to cover all installation practices. Please contact the appropriate City representative for any questions regarding installations or modifications.

**Exemptions:**
No set of rules or instructions will cover all conditions. The Director of Water & Power, or their designee, will consider requests for variances from these requirements and may grant such exemption requests on a case-by-case basis in a timely manner. An **Exemption/Revision Form** must be filled out and submitted online and approved by staff as a condition of service. The form may also be printed and submitted via email with signature to powerdevelopment@cityofloveland.org

**Revisions:**
Due to constant progress in the development of materials and methods, some procedures contained herein may be modified by the City. Proposed revisions to these Requirements may be submitted in writing with documented evidence of the benefits of the change. These proposed revisions will be reviewed by staff to determine the possible benefit to our electric distribution system. Notice will be sent to the author of either acceptance of the change or non-acceptance of the change. Revisions are required for continued application of a work practice, as opposed to an exemption, which is reviewed on a case-by-case basis.

**Updated Standards:**
Revisions to these Standards shall be pursuant to LCUASS 1.6.2. The City will maintain these Standards and any amendments hereto and will post these Standards and amendments on the City’s Internet site. It shall be the responsibility of each customer or contractor to verify the most current Standards are being used for any installation.

This edition of *Requirements for Electric Service* is effective **January 1, 2020**. This book replaces all previous editions of the *Requirements for Electric Service* or *Contractor Construction Standards* books. All previous editions should be destroyed.

The *Requirements for Electric Service* book applies to all new installations, additions to, or modifications of existing installations. Visit [http://www.cityofloveland.org/RES](http://www.cityofloveland.org/RES) to access this document electronically.
IMPORTANT CONTACTS

Locates
CALL 811 BEFORE YOU DIG at least 3 working days in advance.

For Electric questions
Contact our Service Center at 970-962-3000
http://www.cityofloveland.org/departments/water-and-power

Water and Power Service Center
Located at 200 N. Wilson Ave
Hours are Monday through Friday 8:00 a.m. to 5:00 p.m.

Warehouse
Located at 200 N. Wilson Ave.
Hours are 8:00 a.m. to 3:00 p.m.
The documents below are separate from the Requirements for Electric Service document; however, there are references made to these throughout this document.

**City of Loveland Documents**
- Contractor License Application
- Electric Service Worksheet (Commercial)
- Electric Service Worksheet (Residential)
- Exemption/Revision Form
- Interconnection Agreement
- Municipal Code Title 13 Utilities Chapter 13.12 Electricity
- Pulse Metering Request Form
- Schedule of Rates, Charges and Fees
- Solar Photovoltaic Systems Checklist
- Solar Thermal Systems Checklist
DEFINITIONS & ACRONYMS

ANSI – American National Standards Institute

ASTM – American Society for Testing and Materials is an international standards organization that develops and publishes voluntary consensus technical standards for a wide range of materials, products, systems, and services.

Automatic Sectionalizing Device – Means any autonomous circuit-opening device, which can detect fault current & remove the faulted section of the circuit from the upstream circuit and allow restoration of service to the upstream sections of the circuit.

Bi-directional Meter – A meter having two separate metering registers, one to record electricity delivered to the Customer and the other to record electricity received from the Customer.

C-DOT - Colorado Department of Transportation

CIC – Cable in Conduit. Cable and conduit assembly manufactured by loosely extruding High Density Polyethylene conduit around cable assembly.

Certified Equipment – Equipment which has been submitted by a manufacturer to an OSHA-approved nationally recognized testing laboratory, and has been tested and listed by the laboratory for continuous interactive operation with an electric distribution system in compliance with the applicable codes and standards listed in the IEEE 1547 and UL 1741 Standards.

City – Unless otherwise specified, means the City of Loveland Water & Power.

CT – Current Transformer. A device which transforms the primary load current to a secondary current level which is a precise ratio of the primary load current. These are used for transformer rated services above 400amps. (This does not include primary metered services 600 volt and above)

Customer – The party making application for service, or any contractor, electrician or any other authorized agent representing the same. Contractors employed by the City are required to meet these standards.

Customer Space – A single customer address/location or contiguous addresses/locations not separated by a permanent demising wall.

Dedicated Feeder – An Electric Distribution System feeder placed into service with the sole purpose of serving a single Customer. Note that a non-Dedicated Feeder (sometimes referred to as a “Shared Feeder”) serves multiple Customers.

Demarcation Point - The dividing point on the service which marks who is responsible for maintenance and repairs.

Demising - Boundary that separates one tenant’s space from that of the other, and from the common corridor. Also called demising partition or party wall.

DTT - Direct Transfer Trip – The immediate separation of all sources of generation at a DG customer’s location initiated upon the operation of an automatic upstream protection device (substation breaker or line recloser) by means of a dedicated communication channel between the upstream device and the DG location.
Disconnect Switch – A visible open disconnect device that the Customer is required to install and maintain in accordance with the requirements set forth in this book. It will completely isolate the Customer’s Facility from the City’s electric power system, including the Utility metering equipment located at the service entrance.

DG - Distributed Generation – For the purposes of this book shall have the same meaning as DR.

DR – Distributed Resource - An energy generation source that is separate from the main power generation provider and is also connected to the City’s electric distribution system. These can either be owned by the city, or owned by external entities/customers.

Electric Distribution System – A network of power cables, poles, transformers, underground vaults, switches and substations that allow power to be transmitted from a source to a destination. This system also steps the voltage down from transmission levels to customer use levels.

Emergency – An event that is threatening life or property or as otherwise determined by the Director of Water and Power or their designee.

Emergency (Backup) Generator – An independent power generation source or sources located at a Customer’s facility installed for the sole purpose of supplying on site generated power to selected loads upon failure or outage of the normal Utility source. An Emergency (Backup) Generator shall be understood to include a Standby Power System and an Emergency Power System as defined in IEEE STD 446.

Fault Current – The level of current that can flow if a short circuit is applied to a voltage source.

Flicker – A variation of input voltage sufficient in duration to allow visual observation of a change in electric light source intensity.

Harmonic Distortion – Continuous distortion of the normal sine wave; typically caused by nonlinear loads or by inverters.

House Meter – Meters for multiple tenant buildings that measure electrical usage in common areas.

Generating Facility – All or part of the electrical generator(s) or inverter(s) together with all protective, safety, and associated equipment and improvements associated with the interconnection to the City’s electric power system.

Generator – A Rotating Machine or Static Inverter used to produce electrical power.

IEEE – The Institute of Electrical and Electronic Engineers

Interconnection – A point of connection between a customer, power provider, and other utility with Loveland Power. Usually accompanied by a meter panel.

Interconnection Agreement – An agreement, together with appendices, signed between the City of Loveland and the Customer, covering the terms and conditions governing the Interconnection and parallel operation of the Generating Facility with the City of Loveland.

Inverter – A device or system that changes direct current power to alternating current power. Inverters that are self-commutating can be configured for stand-alone service. Inverters that are line-commutated cannot be configured for stand-alone service.

Island – An unplanned condition where one or more generator’s and a portion of the system remain energized solely through the point of interconnection.
**Metering** – The function related to measuring the transfer of electric power and energy.

**Minimum Protective Devices, Relays, and Interconnection Requirements** – These terms are defined as the minimum required protective relaying and/or safety devices or requirements, for the purpose of protecting only the City of Loveland and its other customer facilities from damage or disruptions caused by a fault, malfunction or improper operation of the Customer’s DR. These City Requirements do not include: relaying, protective or safety devices (as required by industry and/or government codes and standards), equipment manufacturing, prudent engineering design and practice to fully protect the Customer’s DR or facilities; those are the sole responsibility of the Customer.

**Nationally Recognized Testing Laboratory (NRTL)** – Shall mean a qualified private organization that meets the requirements of OSHA regulations. NRTLs perform independent safety testing and product certification. Each NRTL must meet the requirements as set forth by OSHA in the NRTL program.

**NEC** – [National Electric Code](#)

**NESC** – [National Electric Safety Code](#)

**NEMA** – [National Electrical Manufacturers Association](#)

**NFPA** – [National Fire Protection Association](#)

**Non-Parallel Connection Agreement** – An agreement, together with appendices, signed between the City of Loveland and the Customer, covering the terms and conditions governing the non-parallel connection and operation of the Generation Facility with the City of Loveland.

**OSHA** – [Occupational Safety and Health Administration](#)

**Parallel** – A Generating Facility that electrically parallels with the City’s electrical power system for more than 15 seconds.

**PCC - Point of Common Coupling** – The point at which the generator facility is connected to the shared portion, or potentially shared portion of the City’s electrical power system. The IEEE STD 1547 standard establishes this point as the location where voltage and harmonic limits are measured and applied.

**PT – Potential Transformer.** A device that transforms the primary load voltage to a secondary voltage, which is a precise ratio of the primary load voltage. These are used for transformer rated meters where service voltages are above 240volts. Also referred to as a voltage transformer (VT).

**Reclosing** – The act of automatically re-energizing a utility line in an attempt to restore power.

**Relay** – An electric device that is designed to interpret input conditions in a prescribed manner and after specified conditions are met to respond to cause contact operation or similar abrupt change in associated electric control circuits.

**ESW – Electric Service Worksheet**

**Self-Contained Metering** - These installations are used on services up to 400 amp single-phase 120/240 volt three-wire and up to 400 amp three-phase 120/208 volt four-wire services, 277/480 volt four-wire services
**Service Upgrade** – Any work that requires changes in the meter socket including but not limited to wiring (line and/or load side), terminations, and meter block. Exemptions may be granted to accommodate repairs to damaged metering equipment. Relocation of service entrance equipment and/or metering equipment and any change that increases the capacity (amperage) of the service entrance equipment or overcurrent protection device are considered service upgrades.

**Single Phasing Condition** – Occurs when one or two phases of the three-phase supply line are disconnected.

**Static Inverter** – An electronic device used to convert direct current (DC) power into alternating current (AC) power.

**SIS - System Impact Study** – A study or studies that may be undertaken by the City’s Power Division (or a designated third party) in response to its receipt of a completed application for Interconnection and parallel operation with the City’s electric power system. Interconnection studies may include, but are not limited to, Interconnection Feasibility Studies, System Impact Studies, and Facilities Studies.

**UL** – [Underwriters Laboratories Inc.](https://www.underwriterslaboratories.com)

**UL Listed** – Distributed Generation equipment identified herein as required to be tested and certified to an applicable UL Standard shall also be listed and labeled according to Section 110.3 of the NEC.

**UFER Grounding** – Is an electrical earth grounding method using concrete-encased electrodes to improve grounding in dry areas.
FOREWORD

Loveland Water and Power has a vision to be recognized by the community for excellence and integrity in providing long-term customer satisfaction and reliable service. To meet this vision, certain rules and regulations are needed to govern the customers’ wiring and installations that are connected to the City’s electric distribution system. These regulations will serve to expedite service connections by establishing uniform standards for electric service. Therefore, customers’ wiring and installations intended for connection to the City’s distribution system must comply with the rules of the City, the National Electrical Code, National Electric Safety Code and any other codes or regulations in effect in the area served. While these regulations are not intended to conflict with other codes or regulations, the City may have requirements that are more stringent and must be adhered to. Any perceived conflicts should be resolved with the City before construction begins.

This booklet has been prepared to assist customers, architects, engineers, contractors, wiremen and inspectors in planning and maintaining electrical installations. It is not intended to ensure adequacy or safety of the customers’ wiring or equipment. Such responsibility remains with the customer.

Distribution Design (970-962-3535) and Electric Metering (970-962-3582) should be contacted in advance of construction or purchase of equipment to resolve possible issues while the project is still in the planning stage. The specification sheets for the equipment should be sent to Electric Metering Supervisor and approved prior to installation in order to ensure that costly changes will not need to be made in order to comply with our specifications. This will resolve issues and minimize the necessity for expensive changes required during the construction stage of the project.
SECTION 1 - GENERAL INFORMATION
1.1 General Requirements

a. **Call for Locates**
   
   CALL 811 BEFORE YOU DIG at least 3 working days in advance.

b. **Dangers & Penalties for Digging into Buried Electrical Installations**
   
   Digging into buried electrical installations can be very dangerous, expensive, and can create hardships for people and businesses from the interruption of service. In addition to the cost of repair, the State of Colorado imposes severe penalties on parties who dig up electrical facilities without calling 811 at least 3 working days in advance (weekends and holidays are not considered working days). We will gladly locate existing City underground electric facilities for you.

c. **Illegal Modifications & Tampering**
   
   The Customer shall not modify or under any circumstance tamper with any City owned facilities.

   All City owned electrical equipment shall be maintained in the color listed in the Material Specification for that equipment. The only exception shall be if the piece of equipment has been selected by the Visual Arts Commission’s Transformations Project.

   Cutting/removing City installed seals on any meter, socket, box or cabinet is prohibited. To do so is illegal and the Customer will be prosecuted according to the Municipal Code.

   All landscaping shall comply with Section 8 – Clearances.

d. **Metered Electrical Power**
   
   All electrical power supplied to customers must be metered except to flat-rate service customers who are approved and accepted by the City. These services will be limited to a 5 amp in-line fuse. (No new flat-rate services will be allowed unless exempted in writing by the Director of Water and Power or their designee.)

e. **Mounting Customer-Owned Equipment**
   
   Customer-owned metering equipment, switching devices, conduits, conductors, luminaires, etc., shall not be mounted on a City owned facility.

f. **Unmetered Yard Lights/ Free Porch Light Program**
   
   Unmetered yard lights are no longer available. Street lighting is provided in the subdivision design plan. For subdivisions with electrical designs approved prior to August 1997, the City will continue to furnish unmetered power to one (1) forty-watt lamp at each residential unit and two (2) forty-watt lamps on corner lots of any residential unit, when requested by the Customer. Upgrades must comply with current NEC requirements. Repairs to unmetered yard light circuits are the responsibility of the Customer. However, the City will maintain the 1 amp fuse supplying the circuit and photocell if applicable.

g. **Disconnect Timeframe**
   
   Request for disconnects require a minimum of two (2) working days.

h. **Permits & Meter Inspections**
   
   Permits and inspections for meters are handled by Loveland Building Division or state electrical inspector. Residential building permits will not be released until a subdivision project has been energized by the City.
i. **Warehouse Hours**
   Materials may be picked up or returned to the Warehouse, Monday through Friday between 8:00 a.m. and 3:00 p.m.

j. **Ownership of Electrical Distribution System**
   The City owns, operates, and maintains all of its overhead and underground electrical distribution facilities, as well as the meter and associated equipment.

1.2 **Overhead and Underground Facilities**

a. **New Services Underground**
   All new utility facilities, shall be located underground throughout new subdivisions and on all new commercial and industrial developments. Upgraded services shall be considered new services and shall be installed underground unless exempted in writing by the Director of Water and Power or their designee.

b. **Convert Overhead Services to Underground**
   In an existing overhead area, customers may request underground service. If sufficient funds are available:
   - The City shall underground existing overhead system upon request of owner or developer
   - The requesting party is to pay all costs of construction and material for the substructure work
   - The City is to pay for wire, terminations, risers and labor
   - The City shall pay all costs associated with removal of the overhead system


1.3 **Electrical Service Voltage Standards**

a. **Standard Services**
   Standard service from the City is single-phase or three-phase 60-hertz alternating current.

b. **Standard Voltage Classification**
   The standard voltage classification is 120/240 single-phase and 120/208 three-phase.

c. **Nominal Secondary Voltages**
   The City offers the following nominal secondary voltages to Customers subject to review and acceptance of application for service.
   - Single-phase, three-wire 120/240, grounded
   - Single-phase, three-wire 120/208, grounded
   - Three-phase, four-wire 120/208 WYE, grounded
   - Three-phase, four-wire 277/480 WYE, grounded
1.4 Service Quality

a. Voltage Level
The voltage level at the Customer’s service entrance varies depending on Customer load, length of service and other factors. The nominal voltage variation will be in accordance with the latest version of ANSI C84.1.

b. Power Irregularities & Interruptions
The City will make every effort to provide a continuous reliable source of power to its Customers. However, the City does not guarantee against irregularities or interruption. The City shall not be considered at fault and shall not be liable for damages resulting from irregularities and interruption of service. Customers with equipment sensitive to service interruptions, voltage irregularities, single phasing, etc. are responsible for taking the necessary precautions to prevent damage from such events.

Customer owned equipment shall not create disturbances or produce harmonic distortion on the system. The City shall require that the Customer take corrective action to prevent a piece of equipment from causing disturbances or harmonic distortion, including disconnection of such equipment at the Customer’s expense. Compliance of this requirement is judged upon the City’s measurement at the demarcation point. In the event that the Customer fails to take corrective action, the City may discontinue electrical service until corrective action is taken.

1.5 Motors and Three-Phase Equipment

a. Air Conditioners & Heat Pumps Requiring Soft Starts
Air conditioners or heat pumps larger than 5 tons shall be required to have a soft start device installed.

b. Motors Requiring Soft Starts
Motor starts may cause unacceptable voltage dips and flicker events for adjacent customers or on the Customer’s service. The following motors require a motor start analysis by the City’s electrical engineering department to determine whether the equipment requires a soft start device:
- Single-phase motors 3hp or larger within the service territory
- Three-phase motors 35hp and larger within the city limits
- Three-phase motors in the Big Thompson Canyon

c. Motor Start Analysis Requirements
The following information shall be provided to the electrical engineering department for the motor start analysis:
- Horsepower rating
- Nameplate full-load amps
- Nameplate locked rotor amps
- Nameplate voltage
- NEMA code letters
- Frequency of starts per time unit

d. Motor Protection Responsibility
The Customer is responsible for motor protection. The motor protection shall meet all NEC requirements for motor protection, including but not limited to current overload, voltage surges/spikes, short circuits, ground faults, low voltage, and single-phasing of three-phase motors.
SECTION 2 - TEMPORARY OVERHEAD & UNDERGROUND
2.1 Temporary Construction Services

a. **Temporary Construction Power**
The City provides temporary construction power where electrical service is required **for a period of 12 months or less.** After the 12 month period, the customer can request a 12 month extension if needed, see Sections 2.2a and 2.3a. Additional extension after 24 months, will be subject to review and approval by the Electric Metering Supervisor. No temporary services are to be utilized as a permanent power source.

b. **Address Posting Requirements**
The Customer shall post the address on or near the temporary power. Posting shall be large enough to be seen from the road and weatherproof.

c. **Location Requirements**
The Customer shall install the temporary power facility (typically a meter pedestal) within 2 to 3 feet of an underground electric source. If a transformer will be the power source, the temporary power facility shall not be located in front of the transformer and shall maintain a minimum clearance of 5 feet. For overhead services, the Customer installs an overhead temporary pole a minimum of ten feet from an existing pole. The temporary facility must meet the requirements of **Drawings No. 2.1 and 2.2.** The temporary pole height for overhead installations must allow for the service wire to meet minimum service drop clearance requirements. See **Table 8-1 in Section 8 - Clearances.**

d. **Conductor Requirements for Underground Temporary Power**
The Customer shall provide a minimum of 36 inches up to a maximum of 48 inches of conductor length exposed at the end of the flex-conduit, with the neutral conductor clearly indicated and a total length sufficient for termination at electric source.

e. **Temporary Pole & Meter Equipment Requirements**
The temporary pole and metering equipment must conform to all current regulations of the City, NEC and NESC, including ground fault protection.

f. **NEC Requirements**
**ALL** requirements for permanent wiring found in the latest version of NEC apply to temporary installations.

2.2 Residential Development Construction Power

a. **Applying for Residential Development Construction Temporary Power**
Prior to applying for a permit from the Building Department, the Customer must complete and submit an **ESW** to the City allowing sufficient time for evaluation and response. New construction temporary power will not require an ESW. If you are demolishing and rebuilding, an ESW will be required.

The Customer must contact the City at 970-962-3535 to schedule a site visit. At the site visit, the Distribution Designer and the Customer will review the scope of work being done by the customer and by the City, along with any fees or deposits that will need to be collected from the Customer for services rendered by the City on an ESW form.

The City will collect fees or deposits required on the form prior to design or construction. The Customer must pay the total estimated cost of the project prior to release of materials or installation. When the final cost is determined, the Customer will be billed or refunded the difference between
the estimated cost and the actual cost. The costs of temporary construction power can be included in the cost of the permanent power.

The Distribution Designer will email a copy of the completed and signed ESW to the customer so they can apply for a permit. The Building Division will collect all permit fees and issue a permit to the Customer.

b. **Building Permits & Fees**
The Customer must apply for a building permit and pay any associated fees to the Building Division prior to issuance of the building permit. All permits shall be obtained before proceeding with construction.

c. **Inspection & Energizing**
The City’s building inspector or state electrical inspector will inspect the installation. Upon inspection approval, the City will set the meter, make the final termination, and energize the installation.

d. **Utility Locates**
The customer or contractor is responsible for obtaining all utility locates prior to excavation. Please call 811 at least 3 working days in advance.

e. **Temporary Meter Poles**
The developer, contractor or electrical contractor shall furnish and install the temporary meter pole in close proximity to power service (power pole, handhole, etc.). The temporary meter pole must meet City and NEC requirements. For a multi-family dwelling, one temporary meter is required per building. See Drawings No. 2.1 and 2.2.

f. **Standard Service Voltage**
The standard service voltage of single-phase 120/240 three-wire service is available for temporary residential construction power applications.

g. **Service Connection Timeframe**
The City will make the connection within three working days from notification date of inspection from building department, unless a line extension of the system is required to provide the power.

h. **Contractor Installed Equipment**
Contractors shall install all metering equipment except the meter.

i. **Approved Meter Sockets**
All service installations must have an approved meter socket with sealing mechanism. All meters shall have lever-operated bypass. See Section 6 – Meters and Meter Connections

j. **Accessible Meter Locations**
All meter equipment must be installed in readily accessible locations. Interior installations are prohibited, as are installations behind or within locked fences, walls and enclosures.

k. **Meter Ground Rods**
Each meter shall have a separate ground rod.

2.3 **Commercial Development Construction Power**
a. **Applying for Commercial Development Construction Temporary Power**
   The Customer must apply for a building permit and pay all associated fees to the Building Division prior to issuance of the building permit. All permits shall be obtained before proceeding with construction. When applying for a permit from the Building Department, the Customer must complete and submit an **ESW** to the City allowing sufficient time for evaluation and response. Included with the ESW, the Customer must submit:
   - Engineering deposit made payable to the City of Loveland
   - Electrical loading information – including main disconnect size/main distribution panel bus size, panel schedules, and connected loads
   - Electrical site plan, one-line electrical drawing, and cut sheets of meter gear/equipment

   Distribution Designers will design the installation and provide an estimated cost. The Customer must pay the total estimated installation cost prior to the release of construction materials. When the final cost is determined, the Customer will be billed or refunded the difference between the estimated cost and the actual cost. Frequently, the costs of temporary construction power can be included in the cost of the permanent power.

b. **Inspection & Energizing**
   The City’s building inspector or state electrical inspector will inspect the installation. Upon inspection approval, the City will set the meter, make the final termination, and energize the installation.

c. **Utility Locates**
   The customer or contractor is responsible for obtaining all utility locates prior to excavation. Please call 811 at least 3 working days in advance.

d. **Standard Services**
   The standard services for temporary construction power applications are single-phase three wire 120/240 volt, single-phase three-wire network 120/208 volts or three-phase four-wire 120/208 wye, grounded volts. This includes services up to 400 amps or less, excluding 120/208 three-wire network services. Temporary 277/480 volt transformers will not typically be installed. Contact the City at 970-962-3582 for special applications.

e. **Meter Socket Requirements**
   The self-contained meter socket must include a lever-operated bypass. Any single-phase three-wire 120/240 volt and single-phase three-wire 120/208 volt service shall have a five-jaw meter socket installed. The fifth jaw shall be installed in the 9 o’clock position and connected to the neutral. All three-phase, four-wire, 120/208 volt services up to 400 amps and 277/480 volt self-contained services up to 400 amps or less shall have a seven-jaw meter socket installed. See **Section 6 – Meters and Meter Connections (no K-Base metering installations allowed)**

f. **No Meters on Utility Poles**
   The City prohibits meter installation on any of its utility poles.

g. **Service Connection Timeframe**
   The City will make the connection within three working days from notification date of inspection from building department, unless a line extension of the system is required to provide the power.
h. **Developer/Contractor Installed Equipment**
   The Developer, Contractor, or Electrical Contractor shall furnish and install all metering equipment and temporary pole except the meter. See *Drawings No. 2.1 and 2.2*. For service greater than 200 amps or three-phase, contact Distribution Design Supervisor at 970-962-3561.

i. **Approved Meter Sockets**
   All service installations must have an approved meter socket with sealing mechanism. All self-contained meter sockets shall have lever-operated bypass. See *Section 6 – Meters and Meter Connections*.

j. **Meter Location Approvals**
   All meter locations shall be approved by the City prior to construction. Please contact the Electric Metering Supervisor at 970-962-3582.

k. **Accessible Meter Locations**
   All meter equipment must be installed in readily accessible locations. Interior installations are prohibited, as are installations behind or within locked fences, walls and enclosures.

l. **Meter Ground Rods**
   Each meter installation shall meet current NEC requirements for grounding and bonding.
NOTES:
1. MUST MEET ALL REQUIREMENTS OF NEC.
2. ALL 15- AND 20-AMPERE, 125- AND 250-VOLT RECEPTACLES TO HAVE IN-USE COVERS.
3. CLEARANCES BETWEEN METALLIC EQUIPMENT, NON-METALLIC EQUIPMENT AND POLES SHALL BE SPECIFIED IN SECTION 8.
Requirements for Electric Service – Section 2 – Temporary Overhead & Underground

ALL NON-CURRENT CARRYING METALLIC PARTS MUST BE EFFECTIVELY GROUNDED.

4" x 4" POLE (MIN)

Address must be visible from the Street

All meter covers must be securable with meter seal

3 or 4 Wire Lever by-pass meter
Ringless socket

Circuit Breakers
(2) 50A (max) must have protective cover attached.

Ground fault interrupters required for all 125-250V
port circuit receptacles. (waterproof)

Flex conduit sized to NEC Code.
All 3 wires must be between 36" and 48" from the end of the flex
conduit. Do not expose wires to damage.

Conduit must be securely fastened to the post

Notes:
1. Must meet all requirements of NEC.
2. All 15- and 20-ampere, 125- and 250-volt receptacles to have in-use covers.
3. Clearances between metallic equipment, non-metallic equipment and poles shall be specified in section 8.
4. City to terminate in transformer or handhole.

CITY OF LOVELAND - DEPARTMENT OF WATER & POWER

<table>
<thead>
<tr>
<th>Date</th>
<th>Drawing No.</th>
<th>Requirements for Electric Service</th>
</tr>
</thead>
<tbody>
<tr>
<td>February 2019</td>
<td>2.2</td>
<td>Temporary Meter Installation Underground</td>
</tr>
</tbody>
</table>
3.1 Residential Service – General

a. **All New Residential and Upgraded services shall be underground.**
   See Section 1.2

b. **Demarcation Point**
   The point of demarcation for underground residential service is the line side jaws of the meter socket. The Customer owns and is responsible for the maintenance of the meter socket. The service entrance wire from the City transformer to the meter base and the meter remains the property of the City. The City maintains this portion of the service. Any damage incurred to the City’s property will be billed at actual cost to the responsible party. The Customer’s electric property will be maintained in a manner that is safe and consistent with City standards. If the Customer’s installation is deemed unsafe by City personnel, an attempt will be made to contact the Customer to repair the problem. If not repaired, the City reserves the right to deny service to the customer.

c. **Additional Fees May Apply**
   The installation fees paid prior to issuance of the building permit covers only standard service installations of 100 feet or less in length and 200 amps or less. Installations exceeding this standard will be charged to the Customer at actual cost for City’s time and material.

d. **Easement Requirements**
   All easements shall be granted to the City of Loveland and certified in writing by a Colorado licensed professional engineer or land surveyor. By submitting an approved ESW, the Customer agrees to grant or arrange for a documented easement on the Customer’s property for the installation, operation, and maintenance of electric lines and/or equipment necessary to provide service to the Customer.

   The easement area shall be at final grade or grade must be within 6 inches of final grade. All obstacles such as construction materials shall be removed before service can be installed.

e. **Utility Locates**
   The customer or contractor is responsible for obtaining all utility locates prior to excavation. Please call 811 at least 3 working days in advance.

f. **Mark Lot Corners**
   Lot corners must be accurately located and marked with pins and stakes except for services with existing power at the lot line. The lot corners must be marked with lot numbers corresponding to the plat map.

g. **Additional Meters on a Single Residential Lot**
   Multiple services and/or meters to separate buildings on one residential lot are not allowed. Additional electric meters are allowed on detached residential occupancy structures if all applicable uses, codes and regulations are met. See Section 3.6 – Additional Service Added

h. **Meter Socket Requirements**
   The Customer is responsible for furnishing and installing an approved meter socket. Refer to Section 6 - Meters and Meter Connections for complete metering requirements. The Customer will be responsible for the load side terminations in the meter socket. The City will make line side terminations.
i. **Accessible Meter & Service Entrance**
   The service entrance and meter must be outside of the building in an easily accessible location approved by the City’s representative. Contact the City at 970-962-3570 prior to construction. Access to the meter shall not be blocked. If the Customer is found to be negligent of said action, removal of the obstruction or relocation of the meter shall be at the Customer’s expense. Refer to *Drawing No. 8.2 in Section 8 - Clearances.*

j. **Construction Standards**
   All Customer owned facilities must meet the current NEC and all applicable portions of the NESC.

k. **Service Entrance Standards**
   The service entrance must meet the current City Standards, NEC, and all applicable portions of the NESC. The City will install the permanent meter upon satisfactory inspection by the electrical inspector.

l. **Keep Area around Service Clear**
   The service conduit shall not pass under or into any permanent structure or landscaping features. The meter shall not be enclosed by building materials or any other permanent structure.

m. **Violations**
   Any additional costs created by violating these requirements will be borne by the Customer.

n. **Grounding Method**
   Grounding per NEC is required.

o. **Customer Installed Item Requirements**
   The Customer is responsible for installing the underground service conduit from the conduit stub adjacent to the handhole (junction box) or transformer pad to the permanent meter location. The conduit stubs are marked by a red colored stake. (If the stake has been removed, contact the City or Distribution Designer to relocate the stub.) See *Drawing Nos. 3.2, 3.3, 3.5 and 3.6.* The installation must comply with the City of Loveland’s Standards and must be inspected by the City’s Power Division at 970-962-3570.

p. **Access Restrictions to City Equipment**
   At no time is the Customer allowed to open or enter the City’s handhole (junction box) or any other City owned electrical equipment. The Customer shall contact the City if access is needed.

q. **600V or less Trench Requirements**
   - The trench bottom shall be smooth, continuous and free of any large rocks or other sharp objects.
   - The top of the conduit shall be a minimum of 24” deep below final grade. The depth shall not exceed 36”.
   - For joint service trench detail, refer to *Drawing No. 5.1 in Section 5 – Trenching & Boring.*
   - The trench shall remain open until the conduit is inspected by the City Power Inspector.

r. **Conduit Requirements**
   - The conduit size shall be 2 ½” PVC SCH 40 conduit. Sweeps must be a minimum 24” radius
   - The Customer shall keep conduit free of dirt and debris during installation.
   - All conduit (sweeps and straight sections) shall be fully seated within the bell ends and glued to prevent infiltration of water into electrical equipment.
• The path between the conduit stub and the meter shall be as straight as possible. The number of conduit bends shall not exceed a maximum of 270 degrees (including the riser sweep).

s. **Slip Coupling Riser Requirements**
A slip coupling riser is required below the meter. The thread size shall be 2 ½” to match the meter canister opening. The inside diameter of the slip riser shall be large enough to fit over the 2 ½” SCH 40 PVC. The 2 ½” PVC shall extend the complete length into the slip coupling riser and be fully seated. The slip coupling riser must be securely attached to the structure.

t. **Warning Tape**
Red electric warning tape shall be installed 12” below final grade directly above the conduit.

u. **Backfill Requirements**
Backfill within 4” of the conduit, on all sides, shall be free of any materials that may damage the conduit system.

v. **Damage Prevention**
Care shall be taken during installation and during backfill around the conduit to ensure that the conduit is undamaged, crushed or deformed. There shall be no internal burrs or sharp edges that will obstruct the cable installation.

### 3.2 New Residential Service with Power at the Lot Line
This section covers single family homes and duplexes with service sizes up to 400 amps with existing power at the lot line. To determine if power is available at the lot line contact the Distribution Design Supervisor at 970-962-3561.

Multiple unit buildings and services larger than 400 amps are considered commercial installations and are covered in Section 4 – Commercial & Industrial.

a. **Applying for New Residential Service with Power at the Lot Line**
The Customer must apply for a building permit and pay any associated fees to the Building Division prior to issuance of the building permit. All permits shall be obtained before proceeding with construction. All fees for this new service will be collected by the Building Department.

b. **Building Permits & Fees**
The Customer must apply for a building permit and pay any associated fees to the Building Division prior to issuance of the building permit. All permits shall be obtained before proceeding with construction.

c. **Inspection & Energizing**
The City’s building inspector or state electrical inspector will inspect the installation. Upon inspection approval, the City will set the meter, make the final termination, and energize the installation.

d. **General Requirements**
See Section 3.1 for General Requirements.
3.3 New Residential Service without Power at the Lot Line
This section covers single family homes and duplexes with service sizes up to 400 amps without existing power at the lot line. To determine if power is available at the lot line contact the Distribution Design Supervisor at 970-962-3561.

Multiple unit buildings and services larger than 400 amps are considered commercial installations and are covered in Section 4 – Commercial & Industrial.

a. Applying for New Residential Service without Power to the Lot Line
Prior to applying for a permit from the Building Department, the Customer must complete and submit an ESW to the City allowing sufficient time for evaluation and response. If you are demolishing and rebuilding, an ESW will be required.

The Customer must contact the City at 970-962-3535 to schedule a site visit. At the site visit, the Distribution Designer and the Customer will review the scope of work being done by the customer and by the City, along with any fees or deposits that will need to be collected from the Customer for services rendered by the City on an ESW form.

The City will collect fees or deposits required on the form prior to design or construction. The Customer must pay the total estimated cost of the project prior to release of materials or installation. When the final cost is determined, the Customer will be billed or refunded the difference between the estimated cost and the actual cost. The costs of temporary construction power can be included in the cost of the permanent power.

The Distribution Designer will email a copy of the completed and signed ESW to the customer so they can apply for a permit. The Building Division will collect all permit fees and issue a permit to the Customer.

b. Building Permits & Fees
The Customer must apply for a building permit and pay any associated fees to the Building Division prior to issuance of the building permit. All permits shall be obtained before proceeding with construction.

c. Inspection & Energizing
The City’s building inspector or state electrical inspector will inspect the installation. Upon inspection approval, the City will set the meter, make the final termination, and energize the installation.

d. General Requirements
See Section 3.1 for General Requirements

3.4 Residential Underground Service Upgrade

a. Applying for Residential Service Upgrade
Prior to applying for a permit from the Building Department, the Customer must complete and submit an ESW to the City allowing sufficient time for evaluation and response. If you are demolishing and rebuilding, an ESW will be required.

The Customer must contact the City at 970-962-3535 to schedule a site visit. At the site visit, the Distribution Designer and the Customer will review the scope of work being done by the customer
and by the City, along with any fees or deposits that will need to be collected from the Customer for services rendered by the City on an ESW form.

The City will collect fees or deposits required on the form prior to design or construction. The Customer must pay the total estimated cost of the project prior to release of materials or installation. When the final cost is determined, the Customer will be billed or refunded the difference between the estimated cost and the actual cost. The costs of temporary construction power can be included in the cost of the permanent power.

The Distribution Designer will email a copy of the completed and signed ESW to the customer so they can apply for a permit. The Building Division will collect all permit fees and issue a permit to the Customer.

b. **Building Permits & Fees**
   The Customer must apply for a building permit and pay any associated fees to the Building Division prior to issuance of the building permit. All permits shall be obtained before proceeding with construction.

c. **Service Disconnects**
   After a building permit has been issued, a service disconnect will be required prior to any service upgrade. Notify Dispatch at 970-962-3581 at least 48 hours in advance to schedule a disconnect. Standard operating hours are 7:30am-3:30pm, work done outside of these hours may incur additional fees. Disconnection shall only be performed by the City. The meter socket/disconnect shall be brought up to current meter standards.

d. **Inspection & Energizing**
   The City’s building inspector or state electrical inspector will inspect the installation. Upon inspection approval, the City will set the meter, make the final termination, and energize the installation. Following inspection, notify Dispatch at 970-962-3581 to schedule a reconnect. Standard operating hours are 7:30am-3:30pm, work done outside of these hours may incur additional fees.

e. **General Requirements**
   See Section 3.1 for General Requirements

### 3.5 Residential Overhead Service Upgrade

Overhead service upgrades are not allowed except through approval by the Director of Water & Power, or their designee. Once an exception has been granted, a residential overhead service upgrade may be applied for.

a. **Applying for Residential Overhead Service Upgrade**
   Prior to applying for a permit from the Building Department, the Customer must complete and submit an ESW to the City allowing sufficient time for evaluation and response. If you are demolishing and rebuilding, an ESW will be required.

   The Customer must contact the City at 970-962-3535 to schedule a site visit. At the site visit, the Distribution Designer and the Customer will review the scope of work being done by the customer and by the City, along with any fees or deposits that will need to be collected from the Customer for services rendered by the City on an ESW form.
The City will collect fees or deposits required on the form prior to design or construction. The Customer must pay the total estimated cost of the project prior to release of materials or installation. When the final cost is determined, the Customer will be billed or refunded the difference between the estimated cost and the actual cost. The costs of temporary construction power can be included in the cost of the permanent power.

The Distribution Designer will email a copy of the completed and signed ESW to the customer so they can apply for a permit. The Building Division will collect all permit fees and issue a permit to the Customer.

b. **Building Permits & Fees**
The Customer must apply for a building permit and pay any associated fees to the Building Division prior to issuance of the building permit. All permits shall be obtained before proceeding with construction.

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d. **Inspection & Energizing**
The City’s building inspector or state electrical inspector will inspect the installation. Upon inspection approval, the City will set the meter, make the final termination, and energize the installation. Following inspection, notify Dispatch at 970-962-3581 to schedule a reconnect. Standard operating hours are 7:30am-3:30pm, work done outside of these hours may incur additional fees.

e. **Demarcation Point**
The point of demarcation for overhead services is the connection at the Customer’s weatherhead. The City provides, owns and installs the service wire up to that point. The Customer owns and is responsible for maintenance of all wire and equipment past that point, with the exception of the City’s metering equipment.

f. **Attachment Point Requirements**
The point of attachment height for the service drop conductor on the Customer’s structure must adequately provide vertical clearances between the service drop and the ground. All clearances must meet the requirements of Drawing No. 3.1 and Table 8-1 located in Section 8 - Clearances.

g. **Connection Point Requirements**
Contractor must provide a suitable connection point for the service drop. The connection point must have adequate strength to safely withstand the strain of the service drop.

h. **Attachment Requirements**
The attachment must safely withstand the strain imposed by the riser. Exercise particular care when installing vertical risers on brick, concrete block, or similar building walls. When attaching the service drop support to a wooden building, attach the service entrance wire holders to the building studs or other structural support. The attachment point is the sole responsibility of the customer.
i. **General Requirements**
   See Section 3.1 for General Requirements

3.6 **Additional Service Added**
When submitting a building permit, make it known that the application is for an additional service. Each metered service will require an address to be assigned through the building permit process.

a. **Applying for Additional Service**
Prior to applying for a permit from the Building Department, the Customer must complete and submit an [ESW](#) to the City allowing sufficient time for evaluation and response.

The Customer must contact the City at 970-962-3535 to schedule a site visit. At the site visit, the Distribution Designer and the Customer will review the scope of work being done by the customer and by the City, along with any fees or deposits that will need to be collected from the Customer for services rendered by the City on an ESW form.

The City will collect fees or deposits required on the form prior to design or construction. The Customer must pay the total estimated cost of the project prior to release of materials or installation. When the final cost is determined, the Customer will be billed or refunded the difference between the estimated cost and the actual cost. The costs of temporary construction power can be included in the cost of the permanent power.

The Distribution Designer will email a copy of the completed and signed ESW to the customer so they can apply for a permit. The Building Division will collect all permit fees and issue a permit to the Customer.

b. **Building Permits & Fees**
The Customer must apply for a building permit and pay any associated fees to the Building Division prior to issuance of the building permit. All permits shall be obtained before proceeding with construction.

c. **Inspection & Energizing**
The City’s building inspector or state electrical inspector will inspect the installation. Upon inspection approval, the City will set the meter, make the final termination, and energize the installation.

d. **Additional Meters on a Single Residential Lot**
Additional electric meters are only allowed on detached residential occupancy structures if all applicable uses, codes and regulations are met. All meters must be accessible to foot and vehicle traffic. This excludes the conversion of a single family dwelling to a multifamily dwelling requiring three or more meters, refer to multiple metering requirements in Section 6.8 – Multiple Metering.

e. **General Requirements**
   See Section 3.1 for General Requirements

3.7 **Mobile, Cottage, or Tiny Home Communities**

a. **General**
For the purpose of this section, one lot with multiple dwelling units is considered commercial and one lot with a single dwelling unit is considered residential.
b. **Lots Owned by Mobile Home Parks-Upgrades**
   If a mobile home park owner requests an upgrade, the owner will pay all resulting charges. See *Section 4.1* concerning commercial requirements.

c. **Lots Owned Individually-Upgrades**
   If the mobile home park lots are sold to an individual owner, that owner shall pay for all charges resulting from upgrades on their lots, including, but not limited to, secondary upgrades and new transformer installations. See *Sections 3.2 and 3.3* concerning residential requirements.

### 3.8 Electrical Substructure in New Subdivisions

a. **Electrical Design, Fees & Contractor Orientation**
   The City will design the electrical system upon the receipt of an engineering deposit, CAD files of the site utility plan showing all wet utilities and known dry utilities, and a full set of construction drawings and site plans. The Customer must pay the total estimated cost of the project prior to release of materials or installation. When the final cost is determined, the Customer will be billed or refunded the difference between the estimated cost and the actual cost. Frequently, the costs of temporary construction power can be included in the cost of the permanent power.

b. **Easement Area Requirements**
   The easement area shall be at final grade and certified in writing by a Colorado licensed professional engineer or land surveyor.

c. **Pre-Construction Meeting**
   An on-site pre-construction meeting with the Distribution Designer and Power Inspector shall be arranged to determine start time and construction schedule for substructure installation. All other utility companies shall be notified of the date and time of this meeting by the developer.

d. **Trenching & Foundation Requirements**
   All trenching and foundations shall meet the requirements of *Section 5 - Trenching & Boring*.

e. **Installation Requirements**
   The installation must conform to all requirements of *Drawing Nos. 3.2, 3.3, 3.5 and 3.6*. 
NOTES:
1. RISERS MUST BE 2" GRC MINIMUM
2. ALL METER SOCKETS SHALL BE RINGLESS AND HAVE LEVER-PASS HANDLE
3. THROUGH ROOF RISER—MAST SHALL BE WITHIN 4' OF EAVE CALLING OF THE MAST MAY BE REQUIRED
4. UNDER EAVE-ATTACHMENT CLEVIS MUST BE SECURED TO THE STUD
5. ALL NON-CURRENT CARRYING METALLIC PARTS MUST BE EFFECTIVELY GROUNDED
6. METER LOCATIONS SHALL BE 3'-5' FROM FRONT CORNER OF HOUSE. SHORTER OR LONGER DISTANCES ALLOWED WHEN APPROVED BY CITY. FENCES SHALL NOT ENCLOSE METER
7. NO METERS SHALL BE LOCATED ABOVE OR BELOW OBSTRUCTIONS (INCLUDING WINDOW WELLS, STAIRS, PLATFORMS ETC.)
8. SEE TABLE 3.1 FOR CLEARANCES.

CITY OF LOVELAND WATER & POWER

<table>
<thead>
<tr>
<th>Date</th>
<th>Drawing No.</th>
<th>Requirements for Electric Service</th>
</tr>
</thead>
<tbody>
<tr>
<td>SEPTEMBER 2019</td>
<td>3.1</td>
<td>RESIDENTIAL OVERHEAD SERVICE</td>
</tr>
</tbody>
</table>
CITY OF LOVELAND WATER & POWER

Date: JULY 2019  Drawing No. 3.3  Requirements for Electric Service
TRANSFORMER BOX PAD LOCATION
SINGLE PHASE TRANSFORMER FOR TEMPORARY SERVICE

NOTES:
1. PROVIDE MIN 5’ CABLE LENGTH ABOVE PAD FOR TERMINATING WHEN USING CIC.
2. 6” MINIMUM DISTANCE TO SIDEWALKS.

CITY OF LOVELAND WATER & POWER

<table>
<thead>
<tr>
<th>Date</th>
<th>Drawing No.</th>
<th>Requirements for Electric Service</th>
</tr>
</thead>
<tbody>
<tr>
<td>SEPTEMBER 2019</td>
<td>3.4</td>
<td>SINGLE PHASE TRANSFORMER FOR TEMP SERVICE</td>
</tr>
</tbody>
</table>
SINGLE PHASE SECTIONALIZING CABINET

NOTE: Transition the trench Depth From 4' To 5'
Deep Twenty Feet Each Side of Cabinet

REVISED FEB 8, 2018 - ADDED NOTE ABOUT LEVEL WORKING SURFACE AROUND CABINET.

CITY OF LOVELAND WATER & POWER

<table>
<thead>
<tr>
<th>Date:</th>
<th>Drawing No.</th>
<th>Requirements for Electric Service</th>
</tr>
</thead>
<tbody>
<tr>
<td>JUNE 2013</td>
<td>3.6</td>
<td>SINGLE PHASE SECTIONALIZING CABINET</td>
</tr>
</tbody>
</table>
RESIDENTIAL UNDERGROUND METER AND SERVICE LOCATIONS

NOTES:
1. FASTEN SECURELY TO WALL PLATE ABOVE FOUNDATION.
2. SINGLE MAIN METER COMBINATION IS REQUIRED IN CASE OF REMOTE METER LOCATION.
3. LONGER OR SHORTER DISTANCES ALLOWED WHEN APPROVED BY CITY.
4. SERVICE ENTRANCE TO BE LOCATED ON THE SIDE OF THE BUILDING CLOSEST TO CITY CONNECTION POINT.
5. NO METERS SHALL BE ABOVE OR BELOW OBSTRUCTIONS INCLUDING WINDOW WELLS, STAIRS AND PLATFORMS.
6. MAIN BREAKER PROVIDED FOR EACH METER, ACCESSIBLE ON OUTSIDE < 10' FROM METER. NO COLD SEQUENCING.
7. PERMANENT LABELS MUST BE FASTENED. SEE METER SECTION 6.
8. ALL NON-CURRENT CARRYING METALLIC PARTS TO BE EFFECTIVELY GROUNDED.
9. METER SOCKET MUST HAVE A LEVER BY-PASS HANDLE.
10. SEE SECTION 6 "METERS AND METER CONNECTIONS" FOR ALL OTHER REFERENCES.
11. CONNECT THE SERVICE CONDUIT TO THE 2 1/2" PVC ELBOW ADJACENT TO THE SECONDARY HANDHOLE. THE PVC ELBOW IS 45 DEGREE – 24" RADIUS CONDUIT AND THE LOCATION WILL BE DESIGNATED WITH A WARNING STAKE MARKED WITH RED TAPE.
12. DO NOT OPEN THE UTILITY HANDHOLE TO ACCESS THE CONDUIT.

CITY OF LOVELAND WATER & POWER

<table>
<thead>
<tr>
<th>Date:</th>
<th>Drawing No.</th>
<th>Requirements for Electric Service</th>
</tr>
</thead>
<tbody>
<tr>
<td>SEPTEMBER 2019</td>
<td>3.7</td>
<td>RESIDENTIAL UNDERGROUND METER &amp; SERVICE LOCATIONS</td>
</tr>
</tbody>
</table>
### RESIDENTIAL 400 AMP SERVICES

![Diagram of residential 400 amp services]

**NOTES:**
1. Fasten securely to wall plate above foundation.
2. Single main meter combination is required in case of remote meter location.
3. Longer or shorter distances allowed when approved by city.
4. Service entrance to be located on the side of the building closest to city connection point.
5. No meters shall be above or below obstructions including window wells, stairs and platforms.
6. 400 Amp Services shall be underground.
7. Main disconnect provided for each meter, accessible on outside < 10' from meter. May install only one 400A disconnect or two 200A disconnects. May install meter-main combo. No cold sequencing.
8. Permanent labels must be fastened. See meter section 6.
9. All non-current carrying metallic parts to be effectively grounded.
10. Meter socket must have a lever by-pass handle and two fine-side lugs for terminating 4/0 cable.
11. See Section 6 "Meters and Meter Connections" for all other references.
12. Connect the service conduit to the 2 1/2" PVC elbow adjacent to the transformer. The PVC elbow is 45 degree - 48" radius conduit.
13. Service cable must be two parallel runs of 4/0 aluminum triplex. DO NOT down-size the neutral wire.
14. DO NOT OPEN THE UTILITY TRANSFORMER TO ACCESS THE CONDUIT.

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**CITY OF LOVELAND WATER & POWER**

<table>
<thead>
<tr>
<th>Date</th>
<th>Drawing No.</th>
<th>Requirements for Electric Service</th>
</tr>
</thead>
<tbody>
<tr>
<td>SEPTEMBER 2019</td>
<td>3.8</td>
<td>RESIDENTIAL 400 AMP SERVICE</td>
</tr>
</tbody>
</table>
SECTION 4 - COMMERCIAL & INDUSTRIAL
4.1 New or Upgraded Commercial & Industrial Service - General

a. All New or Upgraded Commercial and Industrial Services shall be underground.
   See Section 1.2

b. Applying for New or Upgraded Commercial & Industrial Service
   The Customer must apply for a building permit and pay all associated fees to the Building Division
   prior to issuance of the building permit. All permits shall be obtained before proceeding with
   construction. When applying for a permit from the Building Department, the Customer must
   complete and submit an ESW to the City allowing sufficient time for evaluation and response.
   Included with the ESW, the Customer must submit:
   - Engineering deposit made payable to the City of Loveland
   - Electrical loading information – including main disconnect size/main distribution panel bus
     size, panel schedules, and connected loads
   - Electrical site plan, one-line electrical drawing, and cut sheets of meter gear/equipment

   Distribution Designers will design the installation and provide an estimated cost. The Customer
   must pay the estimated installation cost prior to the release of construction materials. The Customer
   must pay the total estimated cost of the project prior to release of materials or installation. When the
   final cost is determined, the Customer will be billed or refunded the difference between the
   estimated cost and the actual cost. Frequently, the costs of temporary construction power can be
   included in the cost of the permanent power.

c. Easement Requirements
   All easements shall be granted to the City of Loveland and certified in writing by a Colorado
   licensed professional engineer or land surveyor. By submitting an approved ESW, the Customer
   agrees to grant or arrange for a documented easement on the Customer’s property for the installation,
   operation, and maintenance of electric lines and/or equipment necessary to provide service to the
   Customer.

   The easement area shall be at final grade or grade must be within 6 inches of final grade. All
   obstacles such as construction materials shall be removed before service can be installed.

d. Utility Locates
   The Contractor is responsible for obtaining all utility locates prior to excavation. Please call 811 at
   least 3 working days in advance.

e. City Furnished Materials & Installation Standards
   For services less than 600 volts and greater than 400 amps, except single-phase and three-phase class
   320, the City furnishes the meter socket, current transformers (CT) and potential transformers (PT),
   where required. The electrical contractor must install the above in accordance with all City
   standards. CTs/PTs shall not be installed in any transformer. They shall be installed in an approved
   CT/ (PT – if above 240 volts) enclosure, within 10’ of the meter on the exterior wall of the building.
   See Section 6 - Meters and Meter Connections, for CT/PT metering requirements.

f. Cable Tray
   Cable trays are not allowed.

g. Wiring Standards
   All wiring on the Customer side must meet the applicable NEC requirements.
h. **Final Inspection Prior to Meter Installation**
The City will install the meter, and instrument wiring if applicable, upon satisfactory final inspection by the inspecting authority. The installation must conform to all metering requirements before the meter is set. The installation area shall be at final grade and meet all acceptable clearances and guidelines.

i. **Pre-Construction Meeting**
An on-site pre-construction meeting with the Distribution Designer and City’s construction inspector shall be arranged to determine start time and construction schedule. All other utility companies shall be notified of the date and time of this meeting by the developer.

j. **Meter Pedestal Installations**
For meter pedestal installations, see Drawing No. 6.3 in Section 6 – Meters and Meter Connections.

### 4.2 Commercial & Industrial Services – Underground

a. **City Work Paid by Customer**
The City shall design, furnish, and energize all primary underground system extensions necessary to provide desired service including the transformer. The Customer bears all costs involved of such installation including but not limited to materials, labor, vehicles, inspection, and engineering. See Section 6.1 – Metering Requirements-General for primary metering.

b. **City Supplied Subsurface Structures**
The Customer or contractor shall install all City supplied subsurface structures required for the primary conductor including conduits and vaults. See Drawings 4.1 and 4.2.

c. **Customer Supplied Items**
The Customer supplies and installs all service cable and conduits from the transformer to the premises in accordance with the NEC.

d. **Demarcation Point**
The demarcation point for underground commercial service is the secondary terminals of the power transformer or secondary connection cabinet. Note that a secondary connection cabinet is allowed only by special approval from the Power Division. The Customer owns, installs and maintains at their expense all wire and equipment past that point, with the exception of the City’s metering equipment.

e. **Underground Service Installations**
For details on installing underground services, refer to Section 5 – Trenching & Boring and Section 8 - Clearances.

### 4.3 Existing Commercial & Industrial Services – Overhead
New overhead services or service upgrades are not allowed.

a. **Demarcation Point**
The point of demarcation for overhead services is the connection at the Customer’s weatherhead. The City provides, owns and installs the service wire up to that point. The Customer owns, installs and maintains at their expense all wire and equipment past that point, with the exception of the City’s metering equipment.
b. **Attachment Point Requirements**

The point of attachment height for the service drop conductor on the Customer’s structure must adequately provide vertical clearances between the service drop and the ground. All clearances must meet the requirements of *Table 8-1 in Section 8 - Clearances*.

Contractor must provide a suitable point of attachment for the service drop. The point of attachment must have adequate strength to safely withstand the strain of the service drop.

c. **Attachment Requirements**

Exercise care when installing vertical risers on brick, concrete block, or similar building walls. The point of attachment must safely withstand the strain imposed by the riser.

When attaching the service drop support to a wooden building, attach the service entrance wire holders to the building studs or other structural support.

Maintaining the attachment point is the responsibility of the owner.

d. **Keep Area around Service Clear**

No structure or object shall be placed underneath the service without permission from the City.
Requirements for Electric Service – Section 4 – Commercial & Industrial

CITY OF LOVELAND WATER & POWER

Date:         Drawing No.         Requirements for Electric Service
SEPTEMBER 2019   4.1             THREE PHASE TRANSFORMER INSTALLATION
COMMERCIAL HANDHOLE

SM. COMM. HANDHOLE
24” x 36” x 24” DEEP
NATIVE BACKFILL
UNDISTURBED SOIL

LC. COMM. HANDHOLE
30” x 48” x 30” DEEP
NATIVE BACKFILL
UNDISTURBED SOIL

RESIDENTIAL HANDHOLE

SM. RES. HANDHOLE
13” x 24” x 18” DEEP
NATIVE BACKFILL
UNDISTURBED SOIL

LC. RES. HANDHOLE
17” x 30” x 18” DEEP
NATIVE BACKFILL
UNDISTURBED SOIL

18” MINIMUM CLEARANCE

NOTES:
1. IF LOCATED IN GRASSY AREA - HEIGHT 2” ABOVE GRADE.
2. IF LOCATED IN ALLEYWAY OR SIDEWALK, THE HANDHOLE SHALL BE FLUSH WITH FINAL GRADE.

CITY OF LOVELAND WATER & POWER

Date: SEPTEMBER 2019

Requirements for Electric Service

Drawing No. 4.2

SECONDARY HANDHOLES
SECTION 5 – TRENCHING & BORING
5.1 Trenching - General

a. **Minimum Separation from Other Utilities**
   Minimum separation (outside conduit wall to outside conduit wall) from primary power conduit and other utilities is required. The following shall apply:
   - Water / Sewer / Storm lines: 6 ft.
   - Natural gas lines: 3 ft.
   - Communications / Other electric utilities: 3 ft.

b. **Minimum Separation for Multiple Conduits**
   Multiple conduits shall have a minimum separation of 3 inches (outside wall to outside wall) from the trench wall and to other conduits. Spacers shall be used and supplied by the City. Four or more 6-inch conduits require City specified concrete duct encasement.

c. **Trench Specifications**
   For Trench Specifications see Drawing No. 5.1.

d. **Excavation Requirements**
   - All excavation work shall conform to standards and codes set forth in the OSHA, Colorado 811, and City regulations. No more trench shall be opened in advance of conduit installation than is necessary to expedite the work.
   - Per Colorado 811’s 2017 Procedures Guide, “Damage Notification Ticket is processed when any underground facility has been damaged or any unknown and/or unmarked facility has been exposed.” Contractor shall note any unknown and/or unmarked facilities on field drawings.

e. **Trench Variances**
   Trenching shall not vary more than 6 inches from the centerline designated on the plans. The City will not accept trenching outside of the right-of-way or easement lines.

f. **Trench Width**
   See Drawing No. 5.1.

g. **Trench Bottoms**
   Trench bottoms should be level and smooth with well-tamped earth. There should not be sharp rises or drops in elevation. Trenches shall be free of sharp rocks, other sharp objects, and foreign material.

h. **Trench Cover**
   See Drawing No. 5.1.

i. **Backfill Materials**
   Backfill material shall be finely divided and free from debris and organic material. Backfill material shall be placed in uniform layers not exceeding 12 inches in un-compacted thickness. The first lift shall contain no rocks larger than 1 inch in the greatest dimension. Subsequent lifts shall contain no rocks larger than 3 inches in the greatest dimension.
j. **Trench Backfill**
Trench backfill at all depths shall be compacted to 90% of maximum density at a moisture content of +/- 2% of optimum moisture content as determined by ASTM D698 or to that of the surrounding undisturbed earth, whichever is less.

Backfill for trenches traversing sub-grades of roads, parking areas, underground piping, street crossings and other facilities subject to damage by settlement shall be compacted to 95% of maximum density at a moisture content of +/- 2% of optimum moisture content as determined by ASTM D698.

All street crossings shall be flowable fill. Flowfill to within 12” from top of subgrade, and from right of way to right of way.

k. **Compaction Methods**
The first lift of backfill material shall be mechanically compacted using platform type tampers. Compaction by rolling will be permitted for the second lift provided the first lift has been adequately consolidated. Water inundation is not allowed as a method of compaction; however, soil may be dampened prior to backfilling to ensure uniform moisture content and adequate compaction.

l. **Compaction Tests**
Compaction tests are the responsibility of the developer for substructure installation. The location and depth of all compaction tests will be designated by the inspector and performed in the presence of the inspector unless excused by the inspector. These tests must be conducted by a certified laboratory and signed by a professional engineer registered in the State of Colorado. Test results must be supplied to the Inspector and Distribution Designer prior to final acceptance.

The frequency of the tests is as follows:
- At least one test for every 300 feet of trench.
- At least two tests at each transformer location. Inspector can designate additional tests at their discretion.

m. **Underground Equipment Inspection**
Pull tape must be passed through each empty duct at the time of installation. The pull tape shall be left in each conduit.

n. **Tracer Wire**
One tracer wire (#12 Red Solid CU THHN) shall be installed with any number of conduits 4-inches and larger. No tracer wire is needed for CIC installations. Tracer wire will be terminated at test boxes. Test boxes will be grounded at a single side.

### 5.2 Boring – General

a. **Description**
The work specified in this section consists of furnishing and installing underground utilities using the directional boring (horizontal directional drilling, HDD) method

b. **Boring Fluid (Mud) System**
Drilling fluid shall be composed of clean water and an appropriate additive. Water shall be from a clean source. No hazardous additives may be used. Boring fluid shall be maintained at a viscosity sufficient to suspend cuttings and maintain the integrity of bore wall. Used boring fluid and boring
fluid spilled during boring operations shall be contained and properly disposed of. A berm, minimum of 12” high, shall be maintained around boring equipment, boring fluid mixing system, entry and exit pits and boring fluid recycling system (if used) to prevent spills into the surrounding environment. Pumps and or vacuum truck(s) of sufficient size shall be in place to convey excess boring fluid from containment areas to storage facilities.

A self-contained, closed, boring fluid mixing system shall be of sufficient size to mix and deliver boring fluid composed of bentonite clay, potable water and appropriate additives. Mixing system shall be able to molecularly shear individual bentonite particles from the dry powder to avoid clumping and ensure thorough mixing. Mixing system shall continually agitate the boring fluid during boring operations.

c. **Equipment**
Pipe rollers, if required, shall be of sufficient size to fully support the weight of the pipe during pull-back operations. Sufficient number of rollers shall be used to prevent excess sagging of pipe. Hydraulic or pneumatic pipe rammers or pullers may only be used if necessary and with the authorization of Engineer.

d. **Record Keeping: As-Buils**
Contractor shall maintain a daily project log of boring operations and a guidance system log with a copy given to the Designer at completion of project. As-built drawings shall be certified as to accuracy by contractor. As-built records shall be provided to the City upon completion of the bore installation.

Third-party verification of as-built drawings may be done, at owner’s expense.

e. **Bore Inspection**
Pull tape must be passed through each empty duct at the time of installation. The pull tape shall be left in each conduit.

### 5.3 Structural Fill, Flowable Fill and Concrete Duct Encasement

a. **Structural Fill**
Structural fill will be used for backfill at all single-phase and three-phase transformer pad installations. See Drawing No. 3.5, Drawing No. 4.1, Section 5.1k - Compaction Methods, and Section 5.11 - Compaction Tests for additional information. Material shall meet Class 1 Structure backfill, conforming to latest version of CDOT Standard Specifications.

<table>
<thead>
<tr>
<th>Class 1 Structure Backfill Material</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Size</strong></td>
</tr>
<tr>
<td>2” (50 mm)</td>
</tr>
<tr>
<td>#4 (4.75 mm)</td>
</tr>
<tr>
<td>#50 (300 μm)</td>
</tr>
<tr>
<td>#200 (75 μm)</td>
</tr>
</tbody>
</table>

In addition, this material shall have a liquid limit not exceeding 35 and a plasticity index of not over six when determined in conformity with AASHTO T 89 and T 90 respectively.
b. **Areas Requiring Flowable Fill**
Flowable fill shall be required under all streets, parking lots and alley ways. Flowfill to within 12” from top of subgrade, and from right of way to right of way.

c. **Flow Fill**
Flow fill will be used at every street crossing. Flow-fill shall have a slump of 9 inches, when tested in accordance with ASTM C143. Material shall conform to latest version of CDOT Standard Specification.

<table>
<thead>
<tr>
<th>Mix Proportions (Per Cubic Yard of Concrete)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cement .50 sack</td>
</tr>
<tr>
<td>Flyash – 50% Replacement</td>
</tr>
<tr>
<td>3/8” Aggregate, ASTM C 33 Size No. 67</td>
</tr>
<tr>
<td>3/4” Aggregate, ASTM C 33 size No. 67</td>
</tr>
<tr>
<td>Sand - ASTM C 33</td>
</tr>
<tr>
<td>Water 35 gals</td>
</tr>
<tr>
<td>Air 3%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
</tr>
</tbody>
</table>

**State Spec Flow Fill**
- Minimum 28-Day Compressive Strength - 60 PSI
- Maximum Aggregate Size - 3/4” – ASTM/AASHTO Size No. 67 Blend
- Type I - II Portland Cement GCC ASTM C 150

<table>
<thead>
<tr>
<th>Mix Design and Performance Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Application</strong></td>
</tr>
<tr>
<td>7 day Strength</td>
</tr>
<tr>
<td>28 day Strength</td>
</tr>
<tr>
<td>Max Aggregate Size</td>
</tr>
<tr>
<td>Slump-at point of placement</td>
</tr>
<tr>
<td>Max: 9”</td>
</tr>
<tr>
<td>Cement</td>
</tr>
</tbody>
</table>

d. **Concrete Duct Encasement**
Concrete duct encasement shall be designed to provide mechanical protection of the duct banks. It also provides a controlled soil resistivity and thermally conductive concrete to help transfer heat away from the power cables. The concrete shall flow in and around the conduit leaving no gaps or air spaces. The complete specification can be furnished upon request.

<table>
<thead>
<tr>
<th>Mix Design and Performance Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Application</strong></td>
</tr>
<tr>
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</tr>
<tr>
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<tr>
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</tr>
<tr>
<td>Slump-at point of placement</td>
</tr>
<tr>
<td>Max: 9”</td>
</tr>
<tr>
<td>Cement</td>
</tr>
</tbody>
</table>

5.4 **Cable Handling**

a. **Unloading Cable Requirements**
Unloading of cable shall be accomplished without contacting the cable or outer covering or supporting the weight of the reel on the cable or covering. This precludes the use of a web sling or inappropriate use of a fork lift or crane.

b. **No Dropping Cable Reels**
Under no circumstances shall reels be dropped from the delivering vehicle to the ground.
c. **Cable Reel Storage Requirements**
   - Reels shall be stored on a hard surface in the upright position. Do not allow the flanges of the reel to sink into a soft surface allowing the weight to be supported on the cable.
   - Do not store cable where it can come in contact with chemicals or petroleum products.
   - Cable shall be stored where it cannot be damaged by construction equipment and flying debris.

d. **Rolling Cable Reel Requirements**
   When rolling reels, clear the path of any objects that could come in contact with the cable.

e. **Seal Cable Ends**
   Exposed cable ends shall be sealed with an appropriately sized cold shrink end cap to prevent environmental and mechanical damage to the cable.

f. **Cable-in-Conduit Length for Vaults**
   Leave a minimum of 25 feet of cable only, not conduit (see *Drawing No. 5.4*), past the inside face of the vault.
NOTES:
1. JOINT TRENCH NOT PERMITTED IN 3 PHASE RESIDENTIAL TRENCHES
2. TRENCHING IN SUB-GRADES OF ROADS, PARKING AREAS, UNDERGROUND PIPING AND OTHER FACILITIES SUBJECT TO DAMAGE BY SETTLING SHALL BE FLOW FILLED OR CONCRETE ENCASED WITH 3" ON ALL SIDES WITH COMPACTED BACKFILL OF 95% MINIMUM AND BE WITHIN 2% OF OPTIMUM MOISTURE. ALL OTHER AREAS MAY BE FILLED WITH BACKFILL AND SHALL BE COMPACTED TO 90% MINIMUM AND BE WITHIN 2% OF OPTIMUM MOISTURE,
3. ALL STREET CROSSINGS SHALL BE FLOW FILLED.
4. DUCT ENCASEMENT IS REQUIRED WHEN THERE ARE FOUR OR MORE 6" CONDUITS.
CITY OF LOVELAND WATER & POWER

<table>
<thead>
<tr>
<th>Date:</th>
<th>Drawing No.</th>
<th>Requirements for Electric Service</th>
</tr>
</thead>
<tbody>
<tr>
<td>SEPTEMBER 2019</td>
<td>5.2</td>
<td>THREE PHASE SECTIONALIZING CABINET</td>
</tr>
</tbody>
</table>
VAULT DETAILS

NOTES:
1. IF VAULT IS TO BE PLACED NEAR A SIDEWALK, ALONG CURB OR OTHER PAVED AREAS, KEEP TOP OF LID LEVEL WITH TOP OF CURB, WALK OR ASPHALT.
2. EXCAVATIONS SHALL EXCEED THE OUTSIDE VAULT WALL DIMENSIONS BY TWO (2) FEET ON ALL SIDES TO PROVIDE FOR TAMMING.
3. EXCAVATION BACKFILL AT ALL DEPTHS SHALL BE COMPACTED TO NOT LESS THAN 90% OF MAXIMUM DENSITY AS DEFINED BY ASTM D698 STANDARD PROCTOR.
4. TOP OF LID SHALL BE 6" ABOVE FINAL GRADE WHEN INSTALLED IN NON-PAVED LOCATIONS.
5. SEE SECTION 8.1 FOR LANDSCAPING CLEARANCE.

CITY OF LOVELAND WATER & POWER

<table>
<thead>
<tr>
<th>Date:</th>
<th>Drawing No.</th>
<th>Requirements for Electric Service</th>
</tr>
</thead>
<tbody>
<tr>
<td>SEPTEMBER 2019</td>
<td>5.3</td>
<td>VAULT DETAILS</td>
</tr>
</tbody>
</table>
CONDUIT DETAIL

SECTION VIEW

NOTES:
1. The ends of the conduit inside the vault shall be deburred, cut square, and secured with spray foam.
2. The conductor shall be extended past the conduit into the vault by a min of 25ft.

CITY OF LOVELAND WATER & POWER

<table>
<thead>
<tr>
<th>Date</th>
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<th>Requirements for Electric Service</th>
</tr>
</thead>
<tbody>
<tr>
<td>SEPTEMBER 2019</td>
<td>5.4</td>
<td>Vault Details - Conduit Detail</td>
</tr>
</tbody>
</table>
5'X5' VAULT

PLAN VIEW

SIDE VIEW

WEIGHT/CONCRETE

LID: 1,200 LBS 0.30 CY
WALLS: 6,102 LBS 1.51 CY
TOTAL: 7,302 LBS 1.81 CY

DESIGN LOADS:
LID: HS-10
VAULT: HS-20-44 WITH IMPACT
SOIL WEIGHT: 120 PSF
LATERAL LIVE LOAD SURCHARGE: 80 PSF
CONCRETE STRENGTH: 6,000 PSI
STEEL STRENGTH: 60,000 PSI
(GRADE 60)

NOTES:
1. TOP OF LID TO HAVE LIGHT BROOM FINISH AND BE EDGED
2. STOCK NUMBER: 93-237-243
3. FERC NUMBER: 361

ALUMINUM ACCESS HATCH W/ 36" X 36" OPENING WITH TWO PENTA-HEAD BOLTS AND HYDRAULIC LIFT ASSIST CAST INTO LID (CENTERED BOTH DIRECTIONS)

TERM-A-DUCT FOR 5" SCH 40, TYP.
4-TON UTILITY ANCHOR CAST INTO INSIDE FACE OF WALL
1-TONX24" SWIFT LIFTS, CAST IN LID, (4) TYP.

E. UFER GROUNDING CLAMP ATTACHED TO REBAR CAGE. FOLLOW MANUFACTURER RECOMMENDATIONS FOR INSTALL. GROUND WIRE EXPOSED TO INSIDE OF WALL, (4 EACH)

CITY OF LOVELAND WATER & POWER

Date: February 2018
Drawing No.: 5.5
Requirements for Electric Service: Vault Details
7'X13' SWG VAULT

PLAN VIEW

SIDE VIEW

END VIEW

WEIGHT/CONCRETE

LID 5,829 LBS 1.44 CY
VAULT 26,200 LBS 6.50 CY
TOTAL 32,029 LBS 7.94 CY

DESIGN LOADS:

LID: HS-10
VAULT: WS-20-44 WITH IMPACT
SOIL WEIGHT: 120 PSF
LATERAL LIVE LOAD SURCHARGES 80 PSF
CONCRETE STRENGTH: 6,000 PSI
STEEL STRENGTH: 60,000 PSI
(GRADE 60)

NOTES:
1. TOP OF LID TO HAVE LIGHT BROOM FINISH AND BE EDGED
2. HATCH MUST OPEN 180°
3. STOCK NUMBER: 93-237-261
4. FERC NUMBER: 361

CITY OF LOVELAND WATER & POWER

Date: February 2018
Drawing No.: 5.7
Requirements for Electric Service: Vault Details
NOTES:
1. CONCRETE BASES SHALL HAVE A LIFER GROUND OR GROUND ROD.
2. STREET LIGHTS SHALL BE PERPENDICULAR TO THE CURB.
3. 2 MINIMUM DISTANCE FROM SIDEWALKS

CITY OF LOVELAND WATER & POWER

Date: SEPTEMBER 2019  
Drawing No. 5.11  
Requirements for Electric Service: CONCRETE BASE FOR STREETLIGHT
CONDUIT CROSSINGS

SEPARATION FROM DRY UTILITIES  SEPARATION FROM WET UTILITIES

FACING VIEW

SIDE VIEW

ELECTRICAL CITY OF LOVELAND

UTILITY

12"

18"

ELECTRICAL CITY OF LOVELAND

UTILITY

ELECTRICAL CITY OF LOVELAND

WET UTILITY

NOTES:
1. THERE WILL BE A MINIMUM DISTANCE OF 12" FROM THE EDGE OF LOVELAND'S ELECTRICAL CONDUIT TO OTHER DRY UTILITIES.
2. THERE WILL BE A MINIMUM DISTANCE OF 18" FROM THE EDGE OF LOVELAND'S ELECTRICAL CONDUIT TO OTHER WET UTILITIES.

CITY OF LOVELAND WATER & POWER

Date:  Drawing No.  Requirements for Electric Service

OCTOBER 2019  5.12  UTILITY CROSSING DETAIL

Requirements for Electric Service – Section 6 – Meters and Meter Connections  Page 74
SECTION 6 - METERS AND METER CONNECTIONS
6.1 Metering Requirements – General

a. **Meter Installation Requirements**
   Metering installations must meet all City requirements in effect at the time a new meter is requested. This includes requests to install a new meter in existing equipment not currently being used. Meters will not be set if all requirements are not met. Contact the Electric Metering Supervisor with any questions you might have regarding metering requirements.

b. **Electric Service Delivered to a Single Point**
   All electric service to a dwelling/Customer space shall be delivered at a single point and measured with a single electric meter.
   - Residential and Multi-dwelling units – Residential dwelling units are required to be individually metered with one meter per address. Multi-dwelling units with three or more dwelling spaces may also require a house meter for common electrical usage. Refer to Section 6.8d - House Meter for Multiple Tenant Buildings.
   - Commercial and Industrial with multiple buildings – Facilities with multiple buildings, that will not be served by a primary metering point, shall have each building served by individual metering points and shall comply with all other requirements within this publication.
   - Multi-Tenant Occupancy Buildings –
     - Multi-tenant occupancy buildings that are designed with static Customer spaces shall be individually metered with one meter per address. Space shall be separated by partition/demarcation walls with no other access from adjoining spaces and shall be considered a separate address. House meters for common electrical usage are required. Refer to Section 6.8d - House Meter for Multiple Tenant Buildings.
     - Multi-tenant occupancy buildings that are designed as core/shell buildings with flexible demising walls between customer spaces should be designed with individual metering points for each tenant space.

When tenants occupy more than one customer space, spaces require consolidation of corresponding electric meters to ensure the space is metered at a single point with one meter per address. Consolidation of metering can be accomplished by physical reconfiguration of metering equipment or through virtual consolidation through the City’s aggregated metering process.

When tenants vacate multiple spaces, metering equipment must be separated with individual metering points for each tenant space with one meter per address.

The building owner is responsible for ensuring that mis-wiring does not occur between the tenant spaces. House meters for common electrical usage are required. Refer to Section 6.8 – Multiple Metering for information on mis-wiring liability and House meters. Contact the Electric Metering Supervisor with questions regarding metering requirements on multi-tenant buildings.

c. **Upgrading Equipment/Service to an Existing Building**
   If upgrading equipment/service to an existing building, the site must meet current standards and guidelines set forth by the City and other national codes. Customers may not add or combine an additional meter to accommodate increased load. The existing meter/service and meter equipment must be upgraded to the appropriate size to handle the new load. The cost of upgrading and/or relocation of electric metering is the responsibility of the Customer.
d. **Building Use Changes**
Any building use other than original plans including altering original space may require re-designed metering to accommodate a change in load characteristics at the building owner’s expense. For information, please contact Electric Metering Supervisor.

e. **Compromised or Unauthorized Changes to Meter/Meter Equipment**
If any meter/metering equipment or City requirement is found to be compromised by changes to existing building installation without the documented approval of the City, the building owner will pay the cost to correct the deficiencies.

f. **Electronic Load Data Collection**
The City reserves the right to install and collect various electronic load data from its Customers. Such data remains the sole property of the City of Loveland.

g. **Installation of Emergency or Back-up Generation**
- This section only applies to emergency or back-up generation that is not an interconnected facility. For interconnected facilities, refer to *Section 9 - Interconnection Requirements*
- The City still requires an external and easily accessible main disconnect, this is in addition to the disconnect that is required by NEC 230.70. The building disconnect or a remote control device used to actuate the main distribution panel shall be immediately adjacent to the utility disconnect and meter.
- The customer shall install a permanently attached sign or placard on the main disconnect between the utility meter and building distribution panel stating “Utility Disconnect: Back-up Generation Exists”.

h. **City to Install Locks & Seals**
Only City of Loveland locks and seals shall be installed from the City transformer to the metering equipment. Customers may not install their own locks on any metering equipment. The City has the authority to remove any unauthorized locks. The City reserves the right to install locking devices on Customer-owned equipment, as necessary to ensure safety and eliminate potential revenue losses.

i. **City to Cut Locks & Seals or Remove Meters**
Only authorized and qualified City of Loveland electric utility personnel shall cut seals/locking mechanisms on any gear ahead of and including the metering equipment. All metering equipment belongs to the City of Loveland and shall not be removed or taken.

j. **No Jumpered Sockets**
Under no circumstances shall an electric meter socket be jumpered to provide temporary power. This includes jumpering the permanent meter socket out while the temporary power pole is providing power. If the socket is found to be jumpered, the socket shall be replaced at Customers’ expense before a meter will be installed.

k. **Replace Damaged Meter Socket Lids**
If the meter socket lid is damaged or will not provide the safety and protection that was originally intended, the cover/meter socket shall be replaced at the Customer’s expense before the meter will be re-installed. A disconnect/reconnect may be required, contact Metering Supervisor at 970-962-3582 for fees that may apply.
1. **No Paint & No Obstructions of Meter Covers**
   No painting or obstruction on any part of the meter cover is allowed. Altered meter covers will be replaced at the Customer’s expense.

m. **Approved Meter Sockets**
   All meter sockets shall be approved for applied voltage, current and number of wires.

n. **Self-Contained Meter/Main Breaker Enclosures**
   All self-contained meter/main breaker enclosures shall have a permanent divider between the meter and the Customer’s breaker and a separate cover over each section, to prevent access of the meter from the Customer’s side of the enclosure.

o. **Meter Socket Material Specifications**
   All single-phase 120/240 volt 3-wire self-contained meter sockets rated for up to 400amps or 320amps (continuous duty) and three-phase 120/208 volt, 277/480 volt 4-wire WYE self-contained meter sockets rated for up to 400 amps or 320 amps (continuous duty) shall have a jaw-clamping, lever-operated bypass mechanism that can operate as a continuous duty bypass device.

   Meter sockets shall have ringless style covers with latch capable of accommodating City seal and lock mechanism.

   Two piece lids are not allowed, unless combination meter main equipment is being used.

   Recommended dimensions for individual meter sockets used in underground installations shall be:
   - Up to 200 amp – 19” height by 13” width
   - 320 amp – 26.5” height by 13” width

   Meter sockets should be constructed of galvanized steel, 16-gauge minimum. Non-metallic or aluminum enclosures are not acceptable.

   Meter sockets shall be suitable for outdoor installation, i.e. weatherproof (NEMA 3R, IP, 14, or equivalent).

   Meter socket bypass lever shall be constructed of metal.

   Meter socket shall have a non-tracking polycarbonate safety shield to prevent accidental contact with energized parts.

   All three wire sockets, both single-phase and network, shall have a fifth terminal installed at the 9 o’clock position.

   320 amp meter sockets shall be equipped with anti-inversion clips that prevent normal width terminal blades from being installed in a 320 amp socket.

   All meter socket configurations shall be approved by the Electric Metering Supervisor prior to purchase and installation.

6.2 **Meter & Associated Equipment Locations**
a. **Meter Location Approval**
   Meter location is subject to City approval. All meters and equipment, including service disconnects, must be outside of the building and continuously accessible, at a location approved by the City. An exception is allowed for internal mounting of disconnects for fire pumps as required by NFPA 20, Appendix A.3.

b. **Prohibited Meter Locations**
   Meters shall not be installed over window wells, in stairwells, under stairways, platforms and in parking garages or alcoves. For location questions, please contact Electric Metering Supervisor at 970-962-3582.

c. **Access to Meter Equipment Required by City**
   The City requires the right to enter Customers’ premises and to freely access metering equipment for the purposes of reading, maintenance and emergencies.

d. **Keep Meter Access Clear**
   The Customer shall keep the meter access clear of fences, building additions, vehicles, shrubbery, or other blockage. Allow for clearance after full maturity of plantings. A minimum 3 foot wide access path to all metering equipment must also be maintained by the Customer. If such blockage is present, the City will notify the Customer to permanently remove the blockage. Failure to clear any blockage may result in disconnection of service. The City is not responsible for damage to trees, shrubs, grass, fences and/or other landscaping due to inadequate access. See Drawing No. 6.1 and Section 8 - Clearances.

e. **Sloped/Uneven Final Grades around Meter**
   When the final grade around the meter is sloping or uneven, a 3 foot radius level area is required in front of the meter or meter equipment.

f. **Parking Bollards (Posts)**
   When metering equipment is prone to vehicular damage, the City may require additional protection such as parking bollards (posts) at the Customers’ expense.

g. **Protective Enclosures**
   Where damage to metering equipment occurs or is anticipated, the City may require the Customer to install fencing or a protective metal enclosure with City locking provisions to protect the equipment. The City will determine when protective enclosures are required.

h. **Repeated Damage to Metering Equipment**
   In cases of repeated damage to metering equipment, the Customer will be charged for repair or replacement of equipment and all associated costs. Failure to provide adequate protection to metering equipment and/or the service entrance may result in disconnection of service.

6.3 **Meter Equipment Mounting**

a. **Who Installs & Supplies Metering Equipment**
   Contractors install all metering equipment except the meter in most situations. Overhead primary metering and some special metering applications will be purchased and built by qualified City personnel. Underground primary metering equipment will be specified by City of Loveland Electric Metering, purchased by the customer and maintained by the City. The City supplies and owns all
b. **Meter Mounting**

Metering equipment must be mounted securely on a rigid surface. Metering equipment not mounted to a building structure may be installed on:

- A freestanding concrete wall, or similar.
- An approved metering pedestal. See Drawing No. 6.3.
- The side of a pad-mounted CT cabinet, switchgear, or equipment cabinet, provided the proper clearances and mounting heights are maintained.

c. **Prohibited Meter Mounting Locations**

Meters shall not be mounted on the inside or outside of pad-mounted transformers or on City utility poles.

d. **Mounting Heights**

- **Individual or Horizontally Adjacent Meters** - Individual meter sockets, or meters adjacent to each other horizontally shall be mounted so that the centerline is between 6 feet and 4 feet above finished grade
- **Vertically Stacked Meters** - Vertically stacked multiple metering shall be mounted so that the bottom of the lowest meter is at least 3 feet above final grade and the top of the highest meter is no more than 6 feet. See Drawing No. 3.7 and 6.2.

e. **CT Mounting Requirements**

Wall-mounted CT cabinets shall be installed so that the bottom of the cabinet is at least 3 feet above final grade. Potential transformers (if used) shall be installed within the CT compartment at a maximum mounting height of 6 feet. Refer to Section 6.9–Transformer Rated Metering (CTs & PTs) for detailed requirements. The CT cabinet and meter socket shall be installed so that the meter socket is not obstructed with the cabinet door in the full open position. Mount the meter socket on the latch side of the metering cabinet.

f. **Service Conduit Requirements**

Service conduit shall have no access or cover point of access between the metering equipment and the power transformer. No more than two 90 degree sweeps in less than three feet for transformer rated sockets. Conduit shall be minimum of 1.5-inch diameter. Bonding collar to be installed on either CT or meter socket with #6 copper ground solid or insulated. Install threaded plastic ring on both sides of conduit. Conduit shall not pass through customer side of equipment or customer walls or structures. Conduit from the CT cabinet to the meter shall not be buried.

g. **Metering Clearances**

Metering clearances must comply with Section 8 - Clearances of this book.

6.4 **Sequence of Meter, Service Entrance and Customer Equipment Connections**

a. **Cold Sequencing**

No cold sequencing allowed, except as required by NEC six handle rule.
b. **No Customer Equipment Ahead of Electric Metering**
   No Customer equipment allowed to connect ahead of the electric metering. Any Customer-owned equipment must be connected after the CT compartment or meter socket.

c. **No Separately Derived Power Source Ahead of City Metering**
   No separately derived power source shall be ahead of the City metering string. For any self-generation, please refer to *Section 9 - Interconnection Requirements* for specifications and approval procedure, prior to purchase or installation of equipment.

d. **No Junction Boxes at Meter Sockets or CT Cabinets**
   Meter sockets or CT cabinets shall not be used as a junction box under any circumstance.

### 6.5 Residential (Single Family Homes or Duplexes)

a. **Approved Meter Sockets**
   For all residential, self-contained service installations the Customer will be responsible for the cost to furnish and install an approved lever-operated bypass meter socket with a sealing mechanism. Ring-type meter sockets are not allowed. Two-piece lids are not allowed, unless combination meter-main equipment is being used. Customer main disconnect is required. Disconnect must be either combination meter-main or immediately adjacent to the meter socket on the outside of the building. Contact the Electric Metering Supervisor with any questions you might have.

b. **Demarcation Point**
   See *Section 3.1b – Demarcation Point*

c. **Replacing Meter Pedestals**
   Existing meter pedestals will be replaced with a meter on the house whenever repairs (City expense) or upgrading (Customer expense) are required.

d. **Multi-Family Dwellings with Three or More Meters**
   Multi-family dwellings with three or more meters are considered commercial services and are covered in *Section 6.7 - Commercial and Industrial* and *Section 6.8 - Multiple Metering*.

e. **Residential Services Greater than 400 Amps**
   Residential services greater than 400 amps (class 320 meter) shall be considered commercial services and are covered in *Section 6.7 - Commercial and Industrial*.

### 6.6 Mobile Home Parks

a. **Service Wire Source & Ownership**
   Ownership of the service wire belongs to the City from the power transformer to the line side connections of the meter socket, or wire gutter, if applicable. The wire will be specified and installed by the City.

b. **Terminations**
   Terminations will be made by the City from the load side of the power transformer to the line side of the meter socket. The load side wire connections and wire leading to the mobile home will be the owner’s responsibility. This includes both overhead and underground services.
c. **Demarcation Point**
   The main line to and between the meter pedestal is the responsibility of the City.

d. **Meter Pedestal Approvals & Ownership**
   Metering pedestals must be approved by the Electric Metering Supervisor before purchase and installation. Ownership and maintenance of these pedestals will not be the responsibility of the City of Loveland. See *Drawing No. 6.3.*

6.7 **Commercial and Industrial (Includes Multi-Family Housing with Three or More Dwellings & Residential Services Greater than 400 Amps)**

a. **277/480 Volts up to 400 Amp Services**
   277/480 volt services up to 400 amps will be metered with self-contained metering. When the load is greater than 400 amps PTs with CTs are required.

b. **Self-Contained Meters**
   All commercial self-contained metering shall have manual bypass meter sockets. Bypass lever must supply clamping action on meter spades and also operate continuous duty bypass device. This includes both single-phase and three-phase applications.

c. **Single-Phase Three-Wire, 240 Volts, 400 Amp Services**
   Single-phase three-wire 240 volts, 400 amp services utilize a class 320 meter and require the installation of an approved CL320 meter socket purchased by Customer. The CL320 meter socket must include a jaw-clamping lever bypass that can operate as a 320-amp continuous duty bypass device.

d. **Three-Phase 120/208 volt Four-Wire Services Greater than 400 Amps & Single-Phase Services Greater than 400 Amps**
   All three-phase 120/208 and 277/480 volt four-wire services greater than 400 amps and single-phase services greater than 400 amps will utilize CTs. PTs are required when service voltage is greater than 240 volts and the load is greater than 400 amps. See *Section 6.9 – Transformer Rated Metering (CTs & PTs)* for complete requirements.

e. **Address Posting at Entrance Doors & Meter Sockets**
   All commercial locations shall have the City-assigned address permanently displayed on or above the entrance door. The same address shall be imprinted on a brass tag permanently attached to the customer access panel beside the meter using pop-rivets or self-tapping screws. The alternate location is below the customer’s main disconnect beside the meter. The tag may also be Mylar. Meters will not be installed until addresses are correctly displayed. See *Drawing No. 6.2.* For a single meter installation (for a building with one address), the address tag may be placed on the meter cover.

f. **Address Labeling of Meters**
   Address labeling of meters shall correspond to building permit scheme. These addresses are given by Land Records Management or the Building Division and shall not to be changed by the Customer. Customer re-addressing of the meters by changing number designation is strictly prohibited. If changes are required, contact the Building Division. If improper address labeling is found, the responsible electrician/customer shall bear all costs to correct the installation.
g. **Temporary Meter Design for Services Greater than 200 Amps**
Temporary metering designed for any loads over 200 amps shall be approved by electric metering prior to installation.

h. **Sub-Metering**
Sub-metering is allowed beyond the City of Loveland metering point and may be used by the Customer for informational purposes only as a check meter to determine how the electricity is being distributed. Sub-metering is not allowed as a substitute for City owned revenue metering. Sub-metering for the purposes of resale of electricity is prohibited.

Customer will provide all equipment, including electric meter(s), and such metering will be installed, and maintained by the Customer. Customers may receive reimbursement for electricity used by tenants, lessees or other persons who ultimately receive the electricity provided by the City owned meter through an appropriate allocation procedure.

Resale of electricity is strictly prohibited and the Customer may not charge the end user(s) more than the cost of service to pay the Customer electric bill.

i. **Demarcation Point**
- Underground Services - See Section 4.2d
- Overhead Services - See Section 4.3a
- Primary Metering – Contact Electric Metering Supervisor at 970-962-3582.

j. **Site/Parking Lot Lighting**
A separate electric meter shall not be installed for site/parking lot lighting that is fed from the same service as the “house meter”. Site/parking lot lighting shall be connected to the house panel, unless it is being fed from a separate service. If more than one meter is installed on a single building with multiple addresses, a house meter is required.

### 6.8 Multiple Metering

a. **Address Posting at Entrance Doors & Meter Sockets**
All commercial locations shall have the City-assigned address permanently displayed on or above the entrance door. The same address shall be imprinted on a brass tag permanently attached to the customer access panel beside the meter using pop-rivets or self-tapping screws. The alternate location is below the customer’s main disconnect beside the meter. The tag may also be Mylar. Meters will not be installed until addresses are correctly displayed. See Drawing No. 6.2. For a single meter installation (for a building with one address), the address tag may be placed on the meter cover.

b. **Address Labeling of Meters**
Address labeling of meters shall correspond to building permit scheme. These addresses that are given by Land Records Management or the Building Division are not to be changed by the Customer. Customer re-addressing of the meters by changing number designation is strictly prohibited. If changes need to be made, contact the Building Division. If improper address labeling is found, the responsible electrician/customer shall bear all costs to correct the installation.
c. **Liability for Mis-Wiring or Incorrect Labeling**
The electrician will be held liable for any mis-wiring or labeling at multiple dwellings resulting in billing inaccuracies. Any costs for the City to correct labeling and/or billing errors will be charged to the customer.

d. **House Meter for Multiple Tenant Buildings**
All multiple tenant buildings shall have a meter to measure common electrical usage that is not billable to a single tenant or entity. The meter shall be labeled “house meter”. This meter shall not be used for any tenant space.

e. **Multi-Occupancy Buildings with Individual Tenant Meters**
Individual tenant meters in multi-occupancy buildings will not be installed until such time that the individual units are being finished and permanent demising walls are constructed. ‘Core & Shell’ buildings will only be issued the meter once individual tenant finishes are permitted.

f. **Meter Equipment Approval**
Any pre-manufactured multiple metering equipment must be approved by the electric metering group. Multiple metering equipment must be bus-type construction. Cable-connected multi-metering will not be accepted. Submit cut sheets to Electric Meter Supervisor for approval, prior to purchasing.

g. **120/208 Volts Single-Phase Multiple Metering Equipment**
All 120/208 volts single-phase multiple metering equipment fed by 120/208 three-phase requires factory balanced phases.

### 6.9 Transformer Rated Metering (CTs & PTs)

a. **All single-phase and three-phase Services Greater than 400 Amps**
Single-phase 120/240 volt three-wire services greater than 400 amps, three-phase 120/208 volt four-wire services greater than 400 amps and three-phase 277/480 volt four-wire greater than 400 amps will utilize Current Transformers (CTs) and potential transformers (PT’s).

b. **277/480 Volt Services Greater than 400 Amps**
277/480 volts services greater than 400 amps require Potential Transformers (PTs). The CT cabinet shall have integral PT mounting provisions (See Table 6-3 for minimum dimensions). Electrical conductors shall not be placed be in front of PTs. Refer to Drawing No. 6.6 and Section 6.9f.

c. **Approved CT Cabinets**
CTs and PTs shall only be installed in approved NEMA Type 3R CT cabinets with a hinged door, lockable hasp and fasteners that cannot be removed from the exterior of the cabinet. The cabinet shall be of sufficient size for load and voltage conditions. See Tables 6-1 through 6-3 for minimum dimensions. Keyed door locks are not allowed. The CT cabinet and meter socket shall be installed so that the meter socket is not obstructed with the cabinet door in the full open position. Meter shall be installed on the latch side of cabinet.

d. **Main Disconnects or Combined Service Disconnects**
All CT rated utility metering service installations for tenants will require that a single main disconnect be installed after the metering on the outside of the building and within ten feet of the CT rated service. This disconnect shall be readily accessible at all times. In lieu of a single main
disconnect, the exception would be that after the CT rated utility metering service installation feeding this tenant they can have up to six service disconnects installed on the outside of the building and not to exceed ten feet from this CT rated service. These disconnects shall be readily accessible at all times.

e. **Prohibited Installation Locations**
   Under no circumstances shall CTs or PTs be installed on secondary overhead lines, in pad-mount transformers or inside gutters or raceways.

f. **CT-Rated Metering Request Submittals**
   All CT-rated metering requests require that a one-line diagram be submitted to the Electric Metering Supervisor for approval prior to installation. This shall include the main disconnect or main distribution panel bus rating and service voltage. Submit cut-sheets to Electric Meter Supervisor for CT rated metering equipment for approval prior to purchasing.

g. **Switchgear CT Compartment Requirements**
   For Switchgear CT compartments, barriers shall be installed on all 4 sides of compartment. The compartment shall have no customer installed equipment behind hinged sealable doors. All panels providing access to unmetered conductors shall have fasteners that cannot be removed from either the exterior or the Customer compartment. No conductors, other than those serving the CT compartment and the ground bus shall be installed in or routed through the compartment. 277/480 volts switchgear shall be manufactured with provisions for unobstructed mounting of PTs inside the same compartment as CTs. If switchgear is to have door fronts, there shall be no other customer equipment inside the metering section.

h. **Wall-Mounted Cabinet Requirements**
   Wall-mounted CT cabinets shall be installed so that the bottom of the cabinet is at least 3 feet above final grade. Potential transformers (if used) shall be installed within the CT compartment. CTs and/or PTs shall be installed at a maximum mounting height of 6 feet.

i. **Pad-Mounted Cabinet Approvals**
   Pad-mounted CT cabinets may be used, with approval from the Electric Metering Supervisor.

j. **No Pull Boxes/Junction Boxes at Meter Sockets or CT Cabinets**
   CT cabinets and meter sockets shall not be used as a pull-box or junction box. No connections shall be made in the CT compartment or meter socket to supply another meter, more than one load circuit, or Customer equipment. For multiple loads a switchboard or combination CT/multi-main equipment shall be used. Gutters, raceways and conduit after metering point is allowed.

k. **Conduit Requirements**
   The conduit from the CT cabinet to the meter box shall be of a single piece, minimum 1.5-inch diameter, and no greater than 10 feet in length. No 90-degree hard corners or LB conduit with plate covers are allowed. The total bends of conduit shall not exceed 180 degrees. All conduit shall remain visible for inspection at all times. Conduit shall not pass through customer side of equipment or customer walls or structures. Conduit coming from the CT cabinet to the meter shall not be buried.
l. **Ground Bonds**
   Ground bonds shall be made from the CT can to the meter box by means of continuous #6 solid or stranded copper, bonded with a double lug to the system neutral within the CT compartment. No mechanical bonds are to be solely relied upon. At least one grounding bushing shall be installed on the conduit between meter box and CT can. Plastic end caps shall be installed on each end of conduit. Grounding provisions shall be available in the CT/PT can and meter box.

m. **City Furnished Materials & City Installations**
   The City will furnish the necessary CTs, PTs and meter socket for all CT rated metering installations under 600V. The City will provide and install the wiring between CTs/PTs, meter and associated equipment.

6.10 **Primary Metering**

a. **Primary Metering Installations**
   The City will specify the cabinet, and install all primary metering instrument transformers, cabinet and switches. The Customer shall purchase and have the cabinet delivered to the City, which will be maintained by the City. Contact the Electric Metering Supervisor for specifications and approval prior to purchasing. All primary metering installations will be built by the City and billed on actuals at the customer’s expense. Customer will need to contact the Electric Metering Supervisor at 970-962-3582 for access to the metering cabinet.

b. **Vaults Under Primary Metering Cabinets**
   Any underground primary metering shall have a vault underneath the primary metering cabinet. Electrical Engineering review is required. Contact the Electric Metering Supervisor at 970-962-3582 for specifications. The City will install the vault and primary metering cabinet. Customer will be billed on actuals for time and material. Customer will need to contact the Electric Metering Supervisor at 970-962-3582 for access to the vault.

c. **Meter Sockets & Meter Installations**
   The City will provide and install the meter socket. The electric metering group will wire the metering circuit and install a meter.

d. **Overhead Primary Metering**
   Overhead primary metering is not allowed. The City, at its discretion, will determine whether overhead primary metering will be allowed. Overhead primary metering installations will be built by the City and billed on actuals at the customer’s expense.

e. **Primary Meter Testing & Certification**
   The City will test and verify the primary meter installation upon energizing the service.

f. **Replacing Primary Metering Equipment**
   Any replacement of the primary metering equipment enclosure, including but not limited to mechanical failure or acts of nature will be coordinated by the City. If, during routine testing, the primary CTs and PTs are determined to require replacement, then replacement of items shall be performed by the City. The Customer will be responsible for the enclosure excluding City owned equipment, replacement will be at owner’s expense and billed on actuals.
6.11 Load Pulse Outputs

a. **Load Pulse Outputs**
   Load pulse outputs will be provided after a Customer submits a completed Load Pulse Request Form and payment of applicable fees. This form can be found on the Requirements for Electric services website. Pulse metering charges can be found in the City of Loveland Schedule of Rates, Charges and Fees.

b. **Pulse Output Meters**
   The Customer will purchase, install and maintain the relay’s weatherproof enclosure and the conduit and wiring from the relay to their Energy Management System (EMS). Upon receipt of the completed request form and fee payment from customer to Electric Metering Supervisor, the City will install a pulse output meter, isolation relay and wire between the meter and relay inputs, then notify the contact person when completed. See Drawing No. 6.7.

c. **Energizing Requirements**
   The City will energize and seal the relay and preform relay pulse verification after the Customer has completed the connection between the relay output and the EMS. Contact the Electric Metering Supervisor at 970-962-3582 to schedule energization.

d. **Energy Management System Configuration**
   The City will provide the Customer with the pulse value, based on the standard pulse rate of the meter. It will be the Customer’s responsibility to configure their EMS to utilize the pulse value, as provided. All pulse outputs from the meter to the relay will be three wire, form-C contacts.
## Tables of Minimum Dimensions for CT Cabinets

### - All dimensions are in inches -

<table>
<thead>
<tr>
<th>Table 6-1: Single-Phase 120/240V</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Amps</strong></td>
</tr>
<tr>
<td>400(^1)</td>
</tr>
<tr>
<td>600</td>
</tr>
<tr>
<td>800</td>
</tr>
<tr>
<td>1200(^2)</td>
</tr>
<tr>
<td>1600</td>
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</table>

\(^1\) Class 320 socket used for 400A single-phase

\(^2\) 48x48x12 may also be used

<table>
<thead>
<tr>
<th>Table 6-2: 3-Phase 4-Wire 120/208V (or 240V)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Amps</strong></td>
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<tr>
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</tr>
<tr>
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<tr>
<td>800</td>
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<tr>
<td>1600</td>
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<tr>
<td>2000</td>
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<tr>
<td>3000</td>
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</table>

*See Note 4

<table>
<thead>
<tr>
<th>Table 6-3: 3-Phase 4-Wire 277/480V with dedicated PT mounting provisions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Amps</strong></td>
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<tr>
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</tr>
<tr>
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<tr>
<td>800</td>
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<td>1200</td>
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<tr>
<td>1600</td>
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<tr>
<td>2000</td>
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<tr>
<td>3000</td>
</tr>
</tbody>
</table>

*See Note 4

### Switchgear Metering Notes:

1. Whenever switchgear metering is desired, cut sheets must be submitted to the Electric Meter Supervisor for approval prior to purchase. Unapproved switchgear will not be accepted.

2. Switchgear CT compartments must have barriers on all 4 sides of compartment and hinged sealable doors. All panels providing access to unmetered conductors shall have fasteners that cannot be removed from the exterior.

3. 277/480V switchgear shall be manufactured with factory-installed provisions for unobstructed mounting of PTs inside the same compartment as CTs.

4. CT Type = Bar (B) or Window (W). When ordering a cabinet for window-type CTs, Customer is required to supply bars and mounting brackets.
**METER CLEARANCES**

Any Obstruction Above Meter

Nearest Side Wall Or Obstruction

WORKING SPACE

Notes:
1. See Sec. 6 for all Meter Requirements
2. See Sec. 8 for all Clearances

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CITY OF LOVELAND WATER & POWER

<table>
<thead>
<tr>
<th>Date</th>
<th>Drawing No.</th>
<th>Requirements for Electric Service</th>
</tr>
</thead>
<tbody>
<tr>
<td>February 2017</td>
<td>6.1</td>
<td>Meter Clearances</td>
</tr>
</tbody>
</table>
3 or 4 Wire Meter Sockets
(100A or 200A each) With Solid Buss Connections

Main Breaker
Address Label

(See Note 1)

6' Max.

3' Min to the First Row

NOTES:
1. The multiple meter package furnished should have solid bus bar connections.
2. All non-current carrying metallic parts must be effectively grounded.
3. Include grounding lug for communications ground.
4. All self-contained metering shall have manual bypass lever meter sockets.
5. See Section 6 "Meters and Meter Connections" for all other references.
MANUFACTURED METER PEDESTAL

NOTES:
1. Must meet all requirements of NEC.
2. Footing - 30" Min. set in concrete from base of hole to finished grade. Concrete must also completely surround the pedestal.
3. Install pedestal per manufacturer recommendation.
4. See Section 6 "Meters and Meter Connections" for all other references.

CITY OF LOVELAND WATER & POWER

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<th>Date</th>
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<th>Requirements for Electric Service</th>
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<tbody>
<tr>
<td>February 2017</td>
<td>6.3</td>
<td>Manufactured Meter Pedestal</td>
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</tbody>
</table>
CT RATED METERING

NOTES:
1. Bond meter box ground to CT cabinet with approved copper wire. Install bonding bushings on either end of conduit. Mechanical bonds are not allowed.
2. CT/PT shall be 6' max from finished grade.
3. See Section 6 “Meters and Meter Connections” for all other references.
4. Grade to be level within a 5ft working radius in front of the meter.
CT RATED METERING, 120/208 V, STANDARD CABINET INTERIOR VIEW

NOTES:
1. Bond meter box to CT cabinet with #6 copper wire.
2. Include grounding lug for communications.
3. Line side can be on top or bottom of CT cabinet.
4. Meter sockets or CT Cabinets shall not be used as a junction box under any circumstance.
5. CT shall be 6' max from finished grade.
6. PTs are to be installed on services greater than 240 volts. Please contact Electric Metering Supervisor for gear specifications.
7. See section 6 "Meters and Meter Connections" for all other references.

CITY OF LOVELAND WATER & POWER

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<tr>
<td>February 2018</td>
<td>6.6</td>
<td>CT METERING CABINET</td>
</tr>
</tbody>
</table>
LOAD CONTROL PULSE OUTPUT

Customer Installed Enclosure

Customer Installed Conduit to EMS

City Meter and Meter Socket

City Installed Conduit

RELAY ENCLOSURE INTERIOR (TYPICAL)

RELAY

NOTES:
1. The customer will determine the location and perform the mounting of the relay enclosure, typically within 18" of the meter socket.
2. Customer installed conduit is required from relay enclosure to customer equipment.
3. No additional customer equipment is allowed inside relay enclosure.
4. The power feed to the relay will be fused inside the meter socket. The city will energize the relay after the customer's wiring is completed. The relay feed shall not be used to power any other equipment.
5. See Section 6 "Meters and Meter Connections" for all other references.
SECTION 7 - METER SOCKET CONNECTIONS
### METER SOCKET TERMINAL ARRANGEMENT

<table>
<thead>
<tr>
<th>Type of Service</th>
<th>Self Contained</th>
<th>With Current Transformer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single-Phase 120/240V, 3-Wire</td>
<td>Figure 1</td>
<td>Figure 3</td>
</tr>
<tr>
<td>Single-Phase 120/208V, 3-Wire</td>
<td>Figure 2</td>
<td></td>
</tr>
<tr>
<td>Three-Phase 120/208V, 4-Wire</td>
<td>Figure 5</td>
<td>Figure 4</td>
</tr>
<tr>
<td>Three-Phase 120/240V, 4-Wire</td>
<td>Figure 5</td>
<td>Figure 4</td>
</tr>
<tr>
<td>Three-Phase 277/480V, 4-Wire</td>
<td>Figure 5</td>
<td>Figure 4</td>
</tr>
</tbody>
</table>

**NOTES:**
1. Fig. 2 shall always have the 5th terminal in the 9:00 position.
2. All self-contained meter sockets shall have a lever by-pass handle.

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**CITY OF LOVELAND WATER & POWER**

<table>
<thead>
<tr>
<th>Date</th>
<th>Drawing No.</th>
<th>Requirements for Electric Service</th>
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<tbody>
<tr>
<td>July 2019</td>
<td>7.1</td>
<td>Meter Socket Terminal Arrangement</td>
</tr>
</tbody>
</table>
SINGLE PHASE 120/240 VOLTS
THREE WIRE

Socket Viewed From the Front

Notes:
1. Must have a lever by-pass handle.
2. See Section 6 "Meters and Meter Connections" for all other references.

CITY OF LOVELAND WATER & POWER

Date: JANUARY 2020
Drawing No.: 7.2
Requirements for Electric Service: Meter Connections
THREE WIRE 120/208 VOLTS WYE
TWO STATOR METER AND FIVE TERMINAL SOCKET

Socket Viewed From the Front

Notes:
1. Must have lever by-pass handle.
2. Neutral lug to be installed on the 9:00 position.
3. See Section 6 "Meters and Meter Connections" for all other references.

CITY OF LOVELAND WATER & POWER

<table>
<thead>
<tr>
<th>Date</th>
<th>Drawing No.</th>
<th>Requirements for Electric Service</th>
</tr>
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<tbody>
<tr>
<td>JANUARY 2020</td>
<td>7.3</td>
<td>Meter Connections</td>
</tr>
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</table>
THREE PHASE FOUR WIRE 120/240 VOLTS DELTA SELF CONTAINED 2-STATOR METER

Socket Viewed From the Front

Notes:
1. Must have a lever by-pass handle.
2. See Section 6 "Meters and Meter Connections" for all other references.
Notes:
1. Must have a lever by-pass handle.
2. See Section 6 "Meters and Meter Connections" for all other references.
SECTION 8 - CLEARANCES
8.1 General Clearances

a. **Pad-Mounted Equipment Clearances**
   No bushes, shrubs or trees shall be planted where mature growth may interfere with pad-mounted equipment clearances as outlined below and shown in Drawing No. 8.1:
   - **Vault Clearances**: 10 feet from all sides of vaults with no covering on or over the vault lid
   - **Switchgear Clearances**: 10 feet from the sides of the switchgear
   - **Transformer Clearances**: 10 feet from the doors, 5 feet from all other sides of the transformer
   - **Metering Equipment**: 5 feet from metering equipment
   - **Primary Metering Equipment**: 10 feet from the front and back, 5 feet from the sides of metering equipment

   Full growth diameters of bushes, shrubs and trees will be the determination of where they are planted in relation to the distances from the equipment. A clear path shall be provided from a roadway or parking area to the access point of the equipment. Customer shall remove any obstruction at Owner’s Expense.

b. **Damage Due to Inadequate Access**
   The City is not responsible for damage to or replacement of trees, shrubs and/or grass if cause of damage is due to inadequate access to any of our equipment or facilities.

c. **Parking Bollards (Posts)**
   When City-owned equipment is prone to damage or vandalism, the City may require the Customer to install (or the City may install) at the Customer’s expense additional protection such as parking bollards (posts), protective enclosures or fencing. Locations of parking bollards and posts will be determined by the City to ensure access and operation of City owned equipment.

d. **Clearances from Windows & Doors**
   Refer to Drawing No. 8.4 for clearances from walls, openings, and overhangs.

8.2 Overhead Clearances

a. **Overhead Clearance Table**
   Refer to Table 8-1 for clearances for service drops and drip loops.

8.3 Underground Clearances

a. **Underground Clearances Drawing**
   Refer to Note 3 in Drawing No. 8.2 for underground clearances.

b. **Pad-Mounted Equipment Clearances**
   For all pad-mounted equipment, the City requires a minimum of 10 feet of clear space in front of all access doors to allow for hot-stick operation. Refer to Drawing No. 8.1.

c. **Permanent Structures Not Permitted Above Underground Conductors**
   No permanent structure shall be constructed over any existing underground conductor. Permanent structures shall have 5 feet horizontal clearance from any existing underground conductor. Temporary structures may be required to be relocated at the owner’s expense if requested by the City.
8.4 Swimming Pools or Hot Tubs/Spas

a. *Swimming Pool or Hot Tubs/Spas Clearances*
   Refer to *Drawing No. 8.3* for clearances from swimming pools or hot tubs/spas.

8.5 Flammable Gases or Liquids

a. *Tanks of Flammable Gases or Liquids Clearances*
   Refer to *Drawing No.8.5* for clearances from tanks containing flammable gases or liquids.
The Customer shall provide a point of attachment which allows NESC minimum clearances to be met in all conditions. A two-foot addition to certain NESC values is required by the City to ensure minimum clearances are met in extreme conditions and after conductor sag. These required heights are noted as “clearance required at time of construction” in the table below. Long services or other special cases (i.e. services crossing uneven or sloped terrain) may require clearance additions greater than two feet. References to applicable codes (NEC, NESC) are italicized.

### Table 8.1 – Clearances for Service Drops and Drip Loops

750 Volts and Below (Distances in Feet)

The Customer shall provide a point of attachment which allows NESC minimum clearances to be met in all conditions. A two-foot addition to certain NESC values is required by the City to ensure minimum clearances are met in extreme conditions and after conductor sag. These required heights are noted as “clearance required at time of construction” in the table below. Long services or other special cases (i.e. services crossing uneven or sloped terrain) may require clearance additions greater than two feet. References to applicable codes (NEC, NESC) are italicized.

<table>
<thead>
<tr>
<th>Service drop clearance (NESC Table 232-1, NEC clearance for this section is 18’ – Art.230.24(B)(4))</th>
<th>NESC Minimum Clearance</th>
<th>Clearance Required at Time of Construction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Over roads, streets, and other areas subject to truck traffic</td>
<td>16’ 18’</td>
<td></td>
</tr>
<tr>
<td>Over or along alleys, parking lots, and nonresidential driveways</td>
<td>16’ 18’</td>
<td></td>
</tr>
<tr>
<td>Over land travelled by vehicles</td>
<td>16’ 18’</td>
<td></td>
</tr>
</tbody>
</table>

### Clearances over residential driveways (NESC Table 232-1)

If height of building or installation will permit: 16’ 18’

If height of building or installation will not permit and is not subject to truck traffic:

- For service drops 120/240 & 208Y/120 volts: 12’ 14’
- For drip loops of service drops 120/240 & 208Y/120 volts: 10’ 12’

### Clearances over spaces and ways subject to pedestrians/restricted travel only (NESC Table 232-1)

If height of building or installation will permit: 12’ 14’

If height of building or installation will not permit, drip loop clearances may be reduced:

- For 480Y/277 volts (Note 8-b of NESC Table 232-1): 10.5’ 10.5’
- For 120/240 & 208Y/120 volts (Note 8-d of NESC Table 232-1): 10’ 10’

### Clearances from buildings for service drops not attached to the building (NESC Table 234-1)

Vertical clearance over or under balconies and roofs:

- Accessible to pedestrians, if cabled with a grounded bare neutral: 11’ 13’
- Accessible to pedestrians, if open wire or cabled with an insulated neutral: 11.5’ 13.5’
- Not accessible to pedestrians, if cabled with a grounded bare neutral: 3.5’ 5.5’
- Not accessible to pedestrians, if open wire or cabled with an insulated neutral: 10.5’ 12.5’

Horizontal clearance to walls, projections, windows, balconies and areas accessible to pedestrians:

- If cable with grounded bare neutral: 5’ 5’
- If open wire or cabled with an insulated neutral: 5.5’ 5.5’

### Clearances for service drops attached to a building or other installation (over or along the installation to which they are attached; service cable with an effectively grounded bare neutral, NESC 230.C)

From the highest point of roofs, decks or balconies over which they pass:

- If readily accessible (NESC 234.C.3.d.1, NEC 230.24(A), Exception No. 1): 10’ 12’
- If not readily accessible (NESC 234.C.3.d.1, exception 2, NEC 230.24(A), Exception No. 2): 3’ 5’
- Above a not-readily accessible roof and terminating at a (through-the-roof) service conduit or approved support, the service and its drip loops set no less than eighteen inches above the roof. No more than six feet of the service cable passes over the roof or within four feet of the roof edge (NESC 234.C.3.d.1b, NEC 230.24(A), Exception No. 3): 1.5’ 1.5’
- In any direction from windows designed to open (does not apply to service cable above the top level of a window; NESC 234.C.3.d.2, NEC 230.9(A)): 3’ 3’
- In any direction from doors, porches, fire escapes, etc. (NESC 234.C.3.d.3, NEC 230.9(A)): 3’ 3’
PADMOUNTED EQUIPMENT CLEARANCES

MINIMUM DISTANCE REQUIRED FROM PAD

\[ y = 10' \] for short side of vaults and sides of padmounted switchgear
and padmounted metering equipment
5' for padmounted transformers
These clearances are also listed in section 8.1 a - d.

CITY OF LOVELAND WATER & POWER

<table>
<thead>
<tr>
<th>Date:</th>
<th>Drawing No.</th>
<th>Requirements for Electric Service</th>
</tr>
</thead>
<tbody>
<tr>
<td>SEPTEMBER 2019</td>
<td>8.1</td>
<td>Padmounted Equipment Clearances</td>
</tr>
</tbody>
</table>
NOTES:
1. The three-foot distance between windows or doors is intended to give the homeowner some privacy. It may be waived for conductors in conduit when not practical.
2. The meter locations shall be 3'-5' from the front of the house. Shorter or longer distances allowed when approved by city. Fences shall not enclose meter.
3. Clearances for underground service are identical to those shown here.
4. No electrical equipment allowed within 3' on either side of gas fixture.
5. All non-current carrying metallic parts must be effectively grounded.
6. No meters shall be located above or below obstructions (including window wells, stairs, platforms, etc.).

CITY OF LOVELAND WATER & POWER

<table>
<thead>
<tr>
<th>Date:</th>
<th>Drawing No.</th>
<th>Requirements for Electric Service</th>
</tr>
</thead>
<tbody>
<tr>
<td>February 2017</td>
<td>8.2</td>
<td>Minimum Clearance Requirements</td>
</tr>
</tbody>
</table>
CLEARANCE FROM SWIMMING POOLS

NOTES:
1. No underground conductors shall be installed within five (5) feet of a swimming pool or its auxiliary equipment.
2. If five (5) feet is not attainable, supplemental mechanical protection shall be provided.
3. Clearance of overhead services in any direction from swimming pools or its auxiliary equipment shall be 22.5'.
4. It is highly recommended to not put an overhead conductor directly over any swimming pool, or hot tub.

CITY OF LOVELAND WATER & POWER

<table>
<thead>
<tr>
<th>Date:</th>
<th>Drawing No.</th>
<th>Requirements for Electric Service</th>
</tr>
</thead>
<tbody>
<tr>
<td>SEPTEMBER 2019</td>
<td>8.3</td>
<td>Swimming Pool Clearances</td>
</tr>
</tbody>
</table>
MINIMUM CLEARANCES FROM WALLS, OPENINGS AND OVERHANGS

NOTES:
1. All padmounted equipments must have a minimum of ten (10) feet clear area on the door(s) side for hot stick operation.
2. Doors shall face away from building walls, fences, etc.
3. Mechanical protection shall be provided.

Transformers or other oil filled equipment shall not be located within areas indicated with shading.

CITY OF LOVELAND WATER & POWER

<table>
<thead>
<tr>
<th>Date:</th>
<th>Drawing No.</th>
<th>Requirements for Electric Service</th>
</tr>
</thead>
<tbody>
<tr>
<td>June, 2013</td>
<td>8.4</td>
<td>Clearances for Building Openings</td>
</tr>
</tbody>
</table>
NOTES:
1. No padmounted equipment shall be installed within twenty-five (25) feet of the refill valve of a tank containing flammable gas or liquid.
SECTION 9 - INTERCONNECTION REQUIREMENTS FOR GENERATING FACILITIES NO LARGER THAN 2 MVA
9.1 Introduction

a. Introduction

Once plans to connect any distributed resource(s) (DR) have been developed, the customer shall contact the City Power Division with all pertinent information regarding the project. The City Power Division, as well as the other approval authorities at the City of Loveland (City), must review and approve the permit package prior to issuing a building permit for the project.

This section provides a standard for the interconnection of distributed resources within the City’s electric power system. This point of interconnection is referred to as the Point of Common Coupling (PCC). The requirements relevant to the performance, operation, testing, safety considerations, and maintenance of the interconnection are listed within this section.

This section is established as a general guideline to assist the generating facility in understanding the requirements involved in planning and designing an electrical connection with the City’s electric power system. If deviations occur from this section, the changes must be approved by the City Power Division or their designated representative.

All costs associated with the interconnection will be provided by the DR facility including, but not limited to, technical review and analysis by the City Power Division or their designated representative.

DR includes but is not limited to generators (including emergency and standby generators), energy storage technologies, synchronous machines, induction machines, power invertors/convertors, static power, or photovoltaic systems that are permanently connected to the City’s electrical power system. If the DR does not parallel with the City for more than 100ms, then the DR needs to meet an open transition (“break-before-make”) connection paradigm in order to operate. Assurance of this operating paradigm must be provided to the City Power Division.

9.2 General Requirements for Interconnection

a. Application

The customer must complete the Interconnection Agreement which is located on the City of Loveland’s Water and Power website.

b. System Sizing

The size of the system shall be limited to 100% of the prior year’s operating energy usage for residential and small commercial. The annual estimated output of the system shall be calculated using PVWatts or similar software. In the event that there is no history to draw from, a suitable justification for sizing shall be submitted to the City for approval. A System Impact Study may be required.

b. Permits

The customer shall submit an application for a building permit to the City prior to constructing the distributed resource. The Interconnection Agreement and specified drawings and cut sheets as noted in the online checklist will be submitted with the permit package.

The customer should provide the City Power Division with electrical drawings for review prior to equipment procurement. Drawings provided will consist of single-line meter and relay diagrams,
three-line diagrams (AC) showing connectivity of relays and schematic drawings (DC) indicating tripping schemes for all City Power Division required relays. The single-line meter and relay diagram listing major equipment should be provided to the City prior to ordering relays.

Relay settings for the interconnection are to be submitted to City Power Division for review. The City will review the settings and may include changes or additions to the settings as warranted by the application. It is the responsibility of the generating facility to have all relay settings tested by a certified testing agency. All costs for such testing will be at the generating facilities own expense. After commissioning, copies of the certified test reports are to be provided by the generating facility for the City Power Division.

The City Power Division will review the customer’s design for interconnection acceptance only. The City Power Division will not approve the reliability or adequacy of the customer’s design.

c. Authorization
Once completed, the application will be routed for proper authorization through the City of Loveland. All authorities listed must approve the application prior to the bi-directional meter being set.

d. Codes and Standards
The generating facility and its associated equipment must meet all applicable national, state and local construction, electrical, and safety codes.

The customer shall ensure the system being attached meets all technical specifications and requirements found in this standard.

In general, the installation is to comply with the latest revision and applicable sections of:

- IEEE STD 141, “IEEE Recommended Practice for Electric Power Distribution for Industrial Plants”.
- IEEE STD 142, “IEEE Recommended Practice for Grounding of Industrial and Commercial Power Systems”.
- IEEE STD 929, “Recommended Practice for Utility Interface of Photovoltaic Systems”.
- IEEE STD 1453, “IEEE Recommended Practice for Analysis of Fluctuating Installations on AC Power Systems”.
- IEEE STD 1547.a, “IEEE Standard for Interconnecting Distributed Resources with Electric Power Systems, Amendment 1”.

Requirements for Electric Service – Section 9 – Interconnection Requirements for Generating Facilities no Larger than 2MVA
• IEEE STD 1547.6, “IEEE Recommended Practice for Interconnecting Distributed Resources with Electric Power Systems Distribution Secondary Networks”.
• NFPA 70, National Electrical Code (NEC).
• UL 1741, “Inverters, Converters, Controllers, and Interconnection System Equipment for Use with Distributed Energy Resources”.

In the event of conflict between these documents, the requirements of this section shall take precedence or the more stringent requirement shall be followed. If clarification is necessary, the City Power Division shall be notified for resolution.

e. **Isolation Transformer**

In general, a dedicated isolation transformer is required to step-up or step-down the DR voltage to the interconnection level and to isolate the generating facility from other City customers. The City will review this requirement on a case-by-case basis.

The impedance of the dedicated transformer limits fault currents on the DR bus from the City’s electric power system and limits fault currents on the City’s electric power system from the DR source. Hence, it reduces the potential damage to both parties due to faults.

The transformer must have a delta winding to reduce harmonics entering the City’s electric power system. The delta winding will also reduce the City’s electric power system harmonics entering the DR. An interconnection level fault-interrupting device is required for transformer protection. Lightning arrestors must be installed between the transformer and the fault-interrupting devices and be encompassed by the DR’s relay protection zone.

The DR can connect to the City’s 4-Wire distribution system using one of the following options:

- Wye-Ground/Delta PV interconnection transformer.
- Wye-Ground/Wye-Ground with a Delta tertiary PV interconnection transformer.
- Wye-Ground/Wye-Ground (LV may be ungrounded) PV interconnection transformer with a HV Grounding Transformer.
- Delta/Wye PV interconnection transformer with HV grounding transformer.

For DR interconnections 1MVA and smaller:

- May connect through Wye-Ground/Wye-Ground interconnection transformer without installing a grounding transformer as long as the conditions of effective grounding are met.
- May connect through a Wye-Ground/Wye-Ground or Delta/Wye interconnection transformer without installing a grounding transformer as long as the temporary overvoltage requirements are met.
• A neutral grounding reactor in a Wye-Ground primary of an interconnection transformer may be necessary to limit the ground fault current when a grounding transformer is not used.

A Wye-Ground/Delta transformer may satisfy the requirements for effective grounding due to the absence of a path for the fault current from the City’s distribution to the PV plant.

The neutral of a Wye-Ground primary with an interconnection transformer shall be connected to the City’s neutral conductor regardless of whether it’s connected through a resistor or is solidly grounded.

The design of the PV interconnection transformer shall ensure that the power quality requirements are met.

If used, on the HV side of the interconnection transformer a grounding transformer/reactor shall be sized to keep temporary overvoltages within voltage limits, maintaining grounding requirements and configured as follows:

• The grounding transformer/reactor shall be sized based on the Thevenin Equivalent of the zero (XPV0) sequence and positive (XPV1) reactance at the PCC with the PCC open and shall meet:
  o \( \frac{X_{PV0}}{R_{PV0}} \geq 4; \) and
  o \( X_{PV0} = 0.6 \pm 0.1 \) pu
  o Where 1 pu base is:
    ▪ The total MVA rating of the DR (sum of interconnection transformer MVA ratings) and high side kV rating of the interconnection transformer for grounding transformer sizing; or
    ▪ The MVA and high side kV rating of the interconnection transformer for neutral reactor sizing.
• Be located on the HV side of the interconnection transformer and between the transformer and the isolation/interrupting breaker.
• A grounding transformer can be either:
  o Solidly connected with no fuse to ensure the transformer is in service at all times.
  o Fused or protected with an overcurrent device.
    ▪ In either case the protection shall be monitored and the DR taken offline in the event of a grounding transformer failure.

f. **Fault-Interrupting Devices (Fuses and Circuit Breakers)**

The fault-interrupting device selected by the DR designer must be reviewed and approved by City Power Division for each particular application. There are two basic types of fault-interrupting devices allowed: Circuit Breakers/Reclosers and Fuses. The City Power Division will determine the type of fault-interrupting device required for a DR based on the size and type of the DR, the available fault duty, the local circuit configuration, and the existing City protection equipment.

A three-phase circuit breaker/recloser at the PCC shall automatically separate the DR from the City’s electric power system upon detection of a circuit fault. Additional breakers and protective relays may be installed in the DR for ease in operating and protecting the facility, but they are not required for the purpose of interconnection. The interconnection breaker shall have sufficient capacity to interrupt the maximum available fault current at its location and be equipped with accessories to:

• Trip the breaker/recloser with an external trip signal supplied through a battery (shunt trip).
• Telemeter the breaker/recloser status when required.
• Lockout if operated by protective relays required for interconnection.

Generally, a three-phase circuit breaker or recloser is the required fault-interruption device at the PCC, due to its simultaneous three-phase operation and ability to coordinate with the City’s electric power system line-side devices.

The fault-interrupting device shall operate fast enough to meet the timing requirement of the quickest protection operation and should:

• Operate in no more than 167ms (10 cycles), which includes the protection element detection time for the DR Facility when not equipped with Transfer Trip; and
• Operate within 133ms (8 cycles) for the DR Facility when equipped with Transfer Trip – maximum interrupting device time is dependent on the speed of Transfer Trip communications.

g. **Manual Disconnect Switch**

A manual disconnect switch is required for all DR installations. A City accessible disconnect device must be provided as a means of electrically isolating the City’s electric power system from the DR source. This device shall be used to establish visually open working clearance for maintenance and repair work in accordance with the City’s safety rules and practices. A separate disconnect device must be located at any and all PCC’s within the City. The disconnect switch shall be a gang-operated, three-pole lockable switch.

The switch must be located between the interconnection level fault-interrupting device and the City’s electrical power system. The switch must be furnished and installed by the DR. It will be owned and operated by the City. All switch devices must be approved by City Power Division. City Power Division must inspect and approve the installation before parallel operation is permitted.

The disconnect device shall not be used to make or break parallel operation between the City’s electric power system and the DR. The switch is used solely by the City and is not for use by the customer. The device enclosure (when present) and operating handle shall be kept locked at all times with a City padlock.

The disconnect device shall be physically located for ease of access and visibility to City personnel. The City operated disconnect shall be identified with a City designated switch number plate.

In general, the following specifications apply:

• Disconnect switches shall be rated for the voltage and current requirements of the particular installation.
• Disconnect switches shall be gang-operated.
• Disconnect switches shall be weatherproof and designed to withstand exposure to weather and ice.
• Disconnect switches shall be lockable in both the open/closed positions with a standard City lock.
• Disconnect switch shall meet NEC STD 705.22.
• Disconnect switch shall be located on the outside of the building and located within ten feet of the meter for DR’s located inside a building.
• Disconnect switch shall be clearly marked with signage that it is an AC disconnect for the DR system.
• All PV systems must be supplied with a Rapid Shutdown (ESTOP).
h. **Rapid Shutdown for PV Systems**

The City requires a Rapid Shutdown Switch for all installed PV systems per NEC Article 690. The purpose of the rapid shut down switch is to provide first responders to quickly and easily control the PV system circuits.

PV system circuits installed on or in buildings shall include a rapid shutdown function that controls specific conductors in accordance with NEC Article 690.12 (1) through (5) as follows:

1. Requirements for controlled conductors shall apply only to PV system conductors of more than 1.5m (5ft.) in length inside a building, or more than 3m (10ft.) from a PV array.
2. Controlled conductors shall be limited to not more than 30 volts and 240 volt-amperes within 10 seconds of rapid-shutdown initiation.
3. Voltage and power shall be measured between any two conductors and between any conductor and ground.
4. The rapid-shutdown initiation methods shall be labeled in accordance with NEC Article 690.56(B).
5. Equipment that performs the rapid shutdown shall be listed and identified.
6. Signage must be installed and labeled per NEC Article 690.

i. **Protective Equipment**

City Power Division protection requirements are designed and intended to protect the City’s electric power system only. The City does not assume any responsibility for the protection of the customer’s facility or any portion of the customer’s electrical equipment. The customer is fully responsible for protecting his equipment from damage caused by faults or other disturbances on the City’s electric power system.

Protective equipment specified in this section or in IEEE STD 1547 must be installed at locations where the DR wishes to operate in parallel with the City’s electric power system. This equipment is used to ensure safe and reliable power system operations and to allow disconnection of the facilities generation in the event of a short circuit or another malfunction. The protection equipment for a DR must protect against faults within that facility and faults on the City’s electric power system. A DR must also trip offline (disconnect from the City’s electric power system automatically) when power is disconnected from the line into which the unit is generating. City Power Division requires line-protective equipment to either: 1) automatically clear a fault and restore power; or 2) rapidly isolate only the faulted section so that a minimum number of customers would be affected by any outages.

High-speed fault clearing may also be required, to minimize equipment damage and potential impact to system stability. The requirement for high-speed fault clearing will be determined by City Power Division on a case-by-case basis. Additional relays and protective devices may be required to achieve high-speed clearing, as outlined in the following subsections. Some protection requirements may be standardized; however, most line relaying will depend on generator size and type, number of generators, line characteristics (i.e., voltage, impedance, and ampacity), and the existing protection equipment connected to the City’s electric power system.

Identical DR projects connected at different locations in the City’s electric power system may have widely varying protection requirements and costs. These differences can be due to different line configurations, fault duties and existing relay schemes.
The DR shall install at the PCC, at a minimum, a disconnecting device or switch with generation interrupting capability. Additional protective relays are typically needed to protect the DR adequately. It is the DR’s responsibility to protect its own system and equipment from faults or interruptions originating on both the City side and the DR’s side of the PCC. The DR’s system protection shall be designed, operated, and maintained to isolate any fault or abnormality that would adversely affect the City’s electric power system or the systems of other entities connected to the City’s electric power system. The DR shall, at its own expense, install, operate, and maintain system protection facilities in accordance with applicable City and other applicable government requirements and in accordance with design and application requirements of this section.

The protective relays used for isolating the DR from the City’s electric power system at the PCC must be reviewed and approved by City Power Division and must be set to coordinate with the protective relays at the City line breaker terminals for the line on which the DR is connected. Additional requirements, as to the exact type and style of the protective devices, may be imposed on the DR based on the proposed station configuration or the type of interrupting device closest to the PCC on the City’s electric power system. Any required additional protective equipment required will be at the DR’s cost.

The City Power Division recommends that the DR acquire the services of a qualified electrical engineer to review the electrical design of the proposed DR and ensure that it will be adequately protected.

Generally, fault-interrupting equipment should be located as close to the PCC as possible – typically within one span of overhead line or 200ft. of un-spliced underground cable.

Protective relays must be submitted to City Power Division for approval.

Utility grade relays, meeting the requirements below shall be utilized to meet the requirements of this section and IEEE STD 1547 for any of the following:

- Any single non-certified inverters or rotating machines rated 300kW or larger.
- Where multiple generators rated 300kW or larger in aggregate are protected by a single interrupting device.
- Where multiple generators rated 2000kW or larger in aggregate are connected to the City’s electric system through a single PCC.
- Where multiple generators rated 2000kW or larger in aggregate are connected to the same distribution circuit on the City in close proximity.

Utility grade relays, used by electric utilities, have much higher reliability and accuracy than industrial grade relays. All utility grade relays must include resettable relay targets, and have 5A nominal AC input current. All utility grade relay power supplies must be powered by station battery DC voltage, and the battery system shall include a DC under voltage detection device and alarm. Utility grade protective and control relays must meet the following requirements:

1. Meet or exceed ANSI/IEEE Standards for protective relays (i.e., C37.90, C37.90.1, C37.90.2 and C37.90.3).
2. Have documentation covering application, testing, maintenance, and service.
4. FT-1 switches are required to facilitate testing.
Depending on the size and type of DR project, the City Power Division may waive the requirement for utility grade relays on a case-by-case basis.

j. **Safety, Reliability and Quality of Service**
The DR must design, construct and operate its equipment in a manner that will not degrade the quality of electric service to other City’s electric power customers. The City Power Division reserves the right to specify the quality and determine the adequacy of the DR facilities equipment, installation and operation in any respect that affects safety, reliability and quality of service.

The DR shall design the protection system with sufficient redundancy that the failure of any one component will still permit the DR to be isolated from the City electric power system under a fault condition. Multi-function three-phase protective relays must have redundant relay(s) for back-up. Recommended practice is to use two relays from different manufacturers in order to provide adequate redundancy and security and to avoid a single mode of failure for both levels of protection. Any customer interface protective devices that have potential impact on the City’s electric power system will have to comply with this practice regardless of distribution or transmission line ownership (City of Loveland, Platte River Power Authority (PRPA) and Western Area Power Administration (WAPA)). Protection of customer-owned equipment by two relays from the same vendor is acceptable as long as these relays utilize different operating principles. An example of relays requiring redundancy would be the intertie breaker and the main customer transformer protection.

k. **Isolated Operation**
City Power Division does not allow isolated operation of the distributed resource under any circumstances without resubmitting a new interconnection request or unless specifically identified on the Interconnection Application. To prevent isolated operation, City Power Division requires devices to detect and disconnect the DR in the event of a loss of electrical power at the PCC. Relays will be required to detect faults on the utility system and transfer tripping equipment may be required so that the DR can be disconnected when the City’s breaker or reclosers open.

Anti-islanding requirement can be satisfied by using any of the following methods, subject to the approval of the City Power Division:

1. Direct Transfer Trip (DTT) Scheme.
2. Use of under/over voltage and frequency relays where any remaining load on the line is significantly larger (3 times or better) than the aggregate generation.
3. The generator’s protection package is certified to pass an anti-islanding test (i.e., certified to comply with IEEE STD 1547 by an OSHA listed Nationally Recognized Testing Lab (NRTL)).
4. The inverter is certified to pass an anti-islanding test (i.e., certified to comply with UL 1741 by a NRTL).
5. Non-exporting customer generators with reverse power relaying applied at the PCC. Relays shall be set to pick up above the minimum import sensitivity of the relay.

An inverter’s active anti-islanding scheme is capable of detecting the islanding in most cases. The following exceptions may apply:

- Load and PV Generation Match.
- Too much reactive power is being injected to the feeder through capacitor banks.
• There is a synchronous generator connected to the feeder which tends to hold the frequency after islanding due to its inertia.

1. **Facility System Disturbances**
   The DR must disconnect in the event of a disturbance or malfunction of facility equipment to prevent loss of service to other City customers. The protective equipment must be coordinated with the City’s electric power system protective equipment to ensure proper operation in the event of a fault. City Power Division will coordinate with the DR to provide proper protection equipment coordination.

m. **Utility System Disturbances**
   The DR must promptly disconnect from the City’s electric power system in the event of a utility system disturbance. The City’s electric power system protective relaying will act to promptly disconnect the affected line. The DR on this affected line represents an additional source of power to energize the line. Therefore, the DR must provide a means to automatically disconnect its generation to avoid isolated operation, and protect equipment and personnel. Direct transfer tripping schemes may need to be implemented to prevent damage to the DR during a reclosing operation.

n. **Back-feed to the Utility System**
   In the event of system outage, the DR must never back-feed to the City’s electric power system and must provide protective means to give assurance that the DR will not be connected to a de-energized system. This requirement is to prevent injury to City Power Division personnel during maintenance of the disconnected line.

o. **Power Quality**
   The generating facility must not degrade the quality of service to other City customers such that the service falls outside of City power quality standards. If the DR cannot meet the requirements for Power Quality, the City will disconnect the DR from their system until such time that it can be shown that any Power Quality issue has been corrected.

When in parallel with the City’s electric power system, the DR is expected to operate within the following guidelines:

- Voltage limits per ANSI STD C84.1, “Standard for Electric Power Systems and Equipment” – Voltage ratings (60 Hertz), Range A.

The DR must not create objectionable flicker for other customers that are in violation of IEEE Standards 519, 141 or 1453 on the City’s electric power system.
The maximum harmonic limits for electrical equipment shall be in accordance with IEEE STD 519 to limit the maximum individual frequency voltage harmonic to:

Table 1 – Harmonic Limits

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum individual frequency voltage harmonic</td>
<td>3% of the fundamental frequency</td>
</tr>
<tr>
<td>Voltage Total Harmonic Distortion (THD)</td>
<td>5% on the utility side of the PCC</td>
</tr>
</tbody>
</table>

p. **Grounding**


Considerations for connecting into the City’s distribution system grounding should include a look at the following:

- Economics.
- Control of temporary overvoltages.
- Control of ground-fault currents, and ground relaying.
- Use of grounding transformers.
- Grounding of high-voltage neutral of wye-delta distribution transformers.
- Interconnection of primary and secondary neutral of transformers.

Any connection to the City’s distribution system shall ensure that, for all system conditions, the ratio of the zero-sequence reactance to the positive-sequence reactance, \(X_0/X_1\), is positive and \(\leq 3\), and the ratio of zero-sequence resistance to positive-sequence reactance, \(R_0/X_1\), is positive and \(< 1\) such that the system is effectively grounded per ANSI/IEEE STD C62.92.1, IEEE Guide for the Application of Neutral Grounding in Electric Utility Systems, Part I – Introduction:

- \(X_0/X_1 \leq 3\) and \(R_0/X_1 \leq 1\)

In all cases the systems shall be grounded in accordance with the latest requirements with the National Electric Code (NFPA 70).

9.3 **Emergency Generator Requirements**

There are two methods of transferring electric power supplies between the City’s electric power system source and the emergency generator system: open transition (break-before-make) and closed transition (make-before-break).

a. **Break-Before-Make (Open Transition)**

This method can be accomplished with a double throw transfer switch or an inter-lock scheme that prevents the two systems from operating in parallel. The generation facility’s main breaker shall not be allowed to close until the generator breaker opens. This open transition method does not require any additional protection equipment; however, it does cause the generation facility’s load to experience an outage while transferring back to the City’s electric power system. The length of this transfer depends on the transfer equipment.
“Break-Before-Make” transfer switch requirements:
- City of Loveland Building Department or Larimer County must approve all transfer switches and/or transfer operating schemes.
- The “break-before-make” transfer switch must be of a design, or have an inter-lock, that prevents the transfer switch from closing and connecting the customer’s system with the City’s electric power system unless the emergency generator is already removed from the system.
- The customer shall not connect portable generators to a permanent wiring system unless the interconnection uses a permanently installed transfer switch (“break-before-make”) or a code-approved secure inter-lock scheme.
- Failure to use this type of switch could create a hazardous situation for City Power Division or other service personnel.

b. **Make-Before-Break (Closed Transition)**
A “make-before-break” may be approved by the City Power Division for this type of installation, but the requirements for parallel generation shall be met. Written approval and operating agreements from the City Power Division shall be obtained prior to installation.

This method is used when the customer wants to minimize any loss of power or disturbance to the electric load. With this scheme, the customer's generator and the City’s electric power system are in parallel for a very short time interval during which the customer's load is being transferred between the City’s electric power system source and the emergency generator. Both the transfer from the City’s electric power system to the emergency source and the transfer back can be accomplished without an outage.

“Make-Before-Break” transfer switch requirements:
- City of Loveland Building Department or Larimer County must approve all transfer switches and/or transfer operating schemes.
- The customer shall not connect portable generators to a permanent wiring system unless the interconnection uses a permanently installed transfer switch (“make-before-break”) or a code-approved secure inter-lock scheme. Failure to use this type of switch could create a hazardous situation for City Power Division personnel or other service personnel.
- The transfer switch must be rated for the maximum available fault duty in the event that the transfer switch closes into a fault condition.
- There must be an inter-lock that will trip the main breaker or generator in the event of a failure of the transfer switch so that the unit will not remain paralleled to the City’s electric power system. One way to accomplish this function is with a “failure-to-open” timer.
- The controls for the transfer switch must prevent a parallel condition of the customer generator and the City’s electric power system from existing for an extended time period. Any system that allows a parallel condition to exist for greater than 1 second (60 cycles) on the distribution system will be subject to the additional parallel operation requirements outlined in this section.

Disconnect switch requirements:
- The customer shall provide a manual disconnect, located at the PCC, which will establish a visually open safety clearance for City Power Division personnel working on the City’s electric power system.
• Disconnect must be lockable in either the open or closed positions and operated only by City Power Division personnel.
• Disconnect must be easily accessible, preferably located adjacent to the electric meter.
• Disconnect must have full load break capability.

The “make-before-break” transfer scheme must have adequate control and protection to ensure the City’s electric power system and customer electric systems are in synchronism prior to making the parallel connection. Synchronization is accomplished through the use of an auto-synchronizer (Device 15/25) or a synchronizing relay supervised by a synch-check relay (Device 25).

Since the emergency generators are paralleled with the City’s electric power system, protective devices must be installed that will prevent the customer’s generator from remaining connected in the event of a fault on the City’s electric power system during the transition.

In some installations, the protection requirement may be satisfied through the installation of the reverse power relay (Device 32R). This relay should be installed on the customer’s side of the service transformer that is connected to the City’s electric power system. The relay should trip the customer’s main breaker and must be able to detect transformer core magnetizing power (inrush current). In this manner, reverse power flow is detected before it actually enters the City’s electric power system and other customers’ equipment. This can be accomplished by setting the current level pick up equivalent to 60 percent of the transformer bank magnetizing current. Because this current value will be small, the current transformers associated with the relay must be capable of providing these small currents.

When transferring the customer’s load back to the City’s electric power system, it is possible to have incidental power flow back to the City’s electric power system. By properly setting the synchronizing and/or generator control, this reverse flow can be avoided. However, a short time delay may be required on the reverse power relay to prevent it from tripping the generator unnecessarily each time a transfer is attempted. At no time, should this time delay exceed 1 second (60 cycles).

Again, since the emergency generator is briefly connected in parallel with the City’s electric power system, all transfer schemes of this type must have a dedicated transformer to reduce the possibility that any transfer activities will affect other City customers. A dedicated transformer is also necessary to allow the installation of the reverse power relay scheme.

### 9.4 System Impact Study
A System Impact Study (SIS) shall be performed if it is determined that there may be negative impact to the City’s electric power system and:

1. The aggregate generation capacity is greater than 15% of the native peak load on the City’s distribution system line section.
2. The maximum fault contribution of the DR facility is more than 10% of the maximum available utility system fault at the point of common coupling (PCC).
3. The aggregate generation capacity is greater than the minimum native load on the City’s distribution system line section.

Aggregate generation includes all existing generation that may already be connected on the line along with any requested new generation. It is the total of existing plus new generations.
a. **System Impact Study**

The City will perform the SIS in accordance with the latest revision of IEEE STD 1547.7. The cost of performing the study is at the expense of the DR provider.


Generally, a typical system interconnection study consists of:

- Distribution facilities over-load determination (thermal evaluation).
- Impact on transfer capability over the critical tie-lines/interfaces.
- Transient and voltage stability analysis.
- Impact on fault levels.

The intent of the SIS is to perform a localized short circuit study, power flow and voltage stability analysis to evaluate the impact on the City’s power distribution system and the possible impact to other customers.

A point of emphasis in this SIS should be to determine fault back-feed protection needed due to the low levels of fault contribution from inverter-interfaced DG.

9.5 **Requirements for Interconnection**

The following represents the minimum requirements to provide a safe and reliable interconnection to the City’s electric power system and may require additional equipment if the individual application warrants the use of such equipment.

- **Isolation Requirements:**
  - A three-pole disconnect device or a fused disconnect switch (only with City Power Division’s written approval) that may be locked in the open position and provides visual indication of isolation.
  - A generating source circuit breaker rated for the service to which it is applied.
  - A line voltage relay to prevent the generating source from being connected to a de-energized source.
  - A dedicated delta-wye transformer when a three-phase inverter is installed.
  - Surge arrestors rated for the service to which it is applied.

- **Demand Recording:**
  - Energy and Demand Meter to be supplied by the City at no cost to the facility.

a. **Line Protection**

Line protection relays must coordinate with the protective relays at the City’s electric power system recloser/breaker for the line on which the DR is connected. The City’s electric power system operates a 12.47/7.2kV grounded-wye distribution system. Typical City electric power system protection is for a long radial line where current can flow in one direction only; typical protective relays for this type of line need to be coordinated in only one direction and may not be directional elements. However, there may be instances where current may flow in either direction depending on system conditions. Relays on these portions of the City’s electric power system must be directional. Such modifications to existing relays will be at the DR facility’s cost.

The DR facility relays must be connected to the breaker CT’s in such a way that zones of protection overlap. The line protection schemes must be able to distinguish between generation, load, inrush and fault currents. The City’s electric power system’s existing relay schemes may have to be reset,
replaced, or augmented with additional relays at the DR’s expense, to coordinate with the new DR. The minimum protection that City Power Division typically uses on its own installation is: phase overcurrent, ground overcurrent, and reclosing.

Required relays must be located so that a fault on any phase of the City’s electric power system’s interconnected line(s) shall be detected. If transfer trip protection is required by City Power Division, the DR shall provide all required communication circuits at its expense. Communication circuits may be dedicated cable, microwave, radio, or a fiber optic circuit and shall be designed with sufficient levels of monitoring of critical communication channels and associated equipment. City Power Division will determine the appropriate communication medium to be used on a case-by-case basis. The dedicated communication network may be required to have high-voltage protection equipment on the entrance cable so that the transfer trip equipment can operate properly during fault conditions.

Some portions of the City’s electric power system have provisions for an alternate feed. In some of these locations, generation may not be allowed on line while being fed from an alternate source due to protection coordination issues. Whenever possible, the DR will be given the option of:

1. Paying for any required upgrades so as to stay on line while transferred to the alternate source, or
2. Accepting shutdowns when transferred to the alternate source and not incurring costs for upgrades to the existing system.

b. Generator/Intertie Protection and Control

Single-phase generators must be connected in groups so that an equal amount of generation capacity is applied to each phase of a three-phase circuit. All synchronous, induction and single-phase generators shall comply with the latest NEMA MG-1 Standards, dealing with waveform and telephone interference. Synchronous generators of any size will require: a) synchronizing relays (Device 15/25), synch-check (Device 25), or auto synchronizer (Device 25A) to supervise generator breaker closing, and b) reclose blocking at the City side of the line to which the generator is connected (applies to substation breaker/recloser and line reclosers).

The protection classes for generator interconnection are:

- 5kW and below
- 6-100kW
- 101-500kW
- 501kW to 2,000kW

The following represents the minimum requirements to provide a safe and reliable interconnection. City Power Division may require additional equipment if the individual application warrants the use of such equipment. Additional generator protection requirements may be determined by City Power Division on a case-by-case basis.

- Protective Relaying, 5kW and below:
  - Short Circuit Protection (Thermal overload protection: minimum requirement).
    - Devices 52, 50/51, 51V and 67 as applicable on case-by-case basis.
    - Device 51V not required on induction machines.
  - Isolation Protection (Devices 27, 59, 81O, 81U: minimum requirements).
    - Device 32 is required for peak shaving and no-sale applications where the generating facility is operating in parallel with the City’s electric power system.
May only protection required on inverters.
- Breaker Closing/Reclosing Control (Devices 25, 27R: minimum requirements).
- Ground Fault Protection (Devices 51N or 51G as applicable on a case-by-case basis).
- Direct Transfer Trip (Recloser Operation as applicable on a case-by-case basis).
- Overspeed protection if applicable.

- **Protective Relaying, 6-100kW:**
  - Short Circuit Protection (Devices 52, 51V: minimum requirements).
    - Devices 50/51 and 67 as applicable on case-by-case basis.
    - Device 51V not required on induction machines.
  - Isolation Protection (Devices 27, 59, 81O, 81U: minimum requirements).
    - Device 32 is required for peak shaving and no-sale applications where the generating facility is operating in parallel with the City’s electric power system.
    - Only protection required on inverters.
  - Breaker Closing/Reclosing Control (Devices 25, 27R, 47: minimum requirements).
    - Device 25 and 27R not required on induction machines.
  - Ground Fault Protection (Devices 51N or 51G as applicable on case-by-case basis).
  - Direct Transfer Trip (Recloser Operation as applicable on case-by-case basis).
  - Over/under-speed control for induction generators (Device 15).

- **Protective Relaying, 101-500kW:**
  - Short Circuit Protection (Devices 52, 51V, or 67: minimum requirements).
    - Devices 50/51 as applicable on case-by-case basis.
    - Device 51V not required on induction machines.
  - Isolation Protection (Devices 27, 59, 81O, 81U: minimum requirements).
    - Device 32 is required for peak shaving and no-sale applications where the generating facility is operating in parallel with the City’s electric power system.
  - Breaker Closing/Reclosing Control (Devices 25, 27R, 46, 47: minimum requirements).
    - Device 25 and 27R not required on induction machines.
  - Ground Fault Protection (Devices 64G, 59G or 51G as applicable on case-by-case basis).
  - Direct Transfer Trip (Recloser Operation as applicable on case-by-case basis).
  - Over/under-speed control for induction generators (Device 15).

- **Protective Relaying, 500-2,000kW:**
  - Short Circuit Protection (Devices 52, 51V, or 67: minimum requirements).
    - Devices 50/51 and 67 as applicable on case-by-case basis.
    - Device 51V not required on induction machines.
  - Isolation Protection (Devices 27, 59, 81O, 81U: minimum requirements).
    - Device 32 is required for peak shaving and no-sale applications where the generating facility is operating in parallel with the City’s electric power system.
  - Breaker Closing/Reclosing Control (Devices 25, 27R, 46, 47: minimum requirements).
    - Device 25 and 27R not required on induction machines.
  - Ground Fault Protection (Devices 64G, 59G, or 51G as applicable on case-by-case basis).
  - Direct Transfer Trip (Recloser Operation as applicable on case-by-case basis).
  - Over/under-speed control for induction generators (Device 15).

Figures 1-7 provide example protection diagrams illustrating the recommended protection schemes for synchronous and induction generators connected through a Wye-Wye, Delta-Wye, or Wye-Delta transformer.
c. **Circuit Breaker/Recloser (Device 52)**
   A three-phase, three-pole circuit breaker or recloser is the required fault-interruption device at the PCC for all three-phase connected DR, due to its simultaneous three-phase operation and ability to coordinate with City’s electric power systems line-side devices. A single-phase, one-pole breaker (or fuses) is the required fault interrupting device at the PCC for all single-phase connected DR.

d. **Phase Overcurrent (Device 50/51)**
   Provide tripping of the circuit breaker or recloser in the event of a phase fault. Phase overcurrent relays must be coordinated with the City’s electric power system line-side devices. Overcurrent protection must be able to detect a line-end fault condition. A phase instantaneous overcurrent relay that can see a line fault under sub-transient conditions is required. A phase instantaneous overcurrent relay is not required if a voltage restraint/control (51V) relay is used.

e. **Phase Overcurrent Relay with Voltage Restraint/Voltage Control (Device 51V)**
   These relays are used to detect multi-phase faults and initiate a generator circuit breaker trip. The relays must be located on the individual generator feeder. A group of generators aggregating over 40MW must have an overcurrent relay with voltage restraint located on each generator greater than 10MW. Generators equal to or greater than 40MW must have an overcurrent relay with voltage restraint. An overcurrent relay with voltage control may also be acceptable if it can be set to adequately detect end-of-line faults as verified by City Power Division protection studies.

   - Phase Overcurrent with Voltage Restraint (51V) – suggested settings:
     - Pickup: 125-150% of generator FLA @ 100% Voltage Restraint.
     - Time: Above the knee of the generator decrement curve with constant excitation and coordinated with the slowest downstream feeder relay setting.
   - Phase Overcurrent with Voltage Control (51V) – suggested settings:
     - Pickup: 80-90% of generator \(I_d = 1/X_d\).
     - Time: Above the knee of the generator decrement curve with constant excitation and coordinated with the slowest downstream feeder relay setting.

   **Note**: The 51V function is not useful for induction generators since, if the voltage is low enough to enable overcurrent protection, the generator excitation will not be sustained.

f. **Under/Overvoltage Relay (Device 27/59)**
   This protection is used to trip the circuit breaker when the voltage is above or below the City’s electric power system’s normal operating level. Relays will operate for generator protection and backup protection in the event that the generator is carrying load that has become isolated from the City’s electric power system.
Table 2 – Interconnection System Default Response to Abnormal Voltages

<table>
<thead>
<tr>
<th>Voltage range (% of base voltage b)</th>
<th>Clearing time (s)</th>
<th>Clearing time: adjustable up to and including (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>V &lt; 45</td>
<td>0.16</td>
<td>0.16</td>
</tr>
<tr>
<td>45 ≤ V &lt; 60</td>
<td>1</td>
<td>11</td>
</tr>
<tr>
<td>60 ≤ V &lt; 88</td>
<td>2</td>
<td>21</td>
</tr>
<tr>
<td>110 &lt; V &lt; 120</td>
<td>1</td>
<td>13</td>
</tr>
<tr>
<td>V ≥ 120</td>
<td>0.16</td>
<td>0.16</td>
</tr>
</tbody>
</table>

a Under mutual agreement between the CITY OF LOVELAND and the distributed resource operators, other static or dynamic voltages and clearing time trip settings shall be permitted.

b Base voltages are the normal system voltage stated in ANSI STD C84.1-2011, Table 1.

Table 2 is an excerpt from IEEE STD 1547a-2014, Amendment 1. The latest revision of IEEE STD 1547 voltage tables shall be used.

At a minimum, the 88% and 110% settings shall be used. Under no circumstances shall the voltage exceed 125% on the City’s distribution system.

For voltage excursions outside these limits the protective device shall automatically initiate a disconnect sequence from the utility system as detailed in ANSI/IEEE STD 1547.

For inverter (PV) plant technologies that use voltage source inverters, automatic regulators may be applied to regulate the reactive output, to maintain a certain voltage i.e. at the PCC between the PV plant and power system. For other inverter (PV) plant technologies voltage regulation can come from a supervisory control system to regulate the reactive resources throughout the PV plant.

These set points are intended to ensure that any DR interconnected to the City’s electric power system does not cause the service voltage for other customers to go outside the requirements of ANSI STD C84.1-2011, Table 1.

Note: Inverters that comply with IEEE STD 929-2000, “Recommended Practice for Utility Interface of Photovoltaic Systems,” and UL 1741, “Inverters, Converters, Controllers, and Interconnection System Equipment for Use with Distributed Energy Resources,” have built-in 27/59 functions. If an inverter lacks these functions, then 27/59 relay protection must be installed.

g. Over/Under Frequency Relay (Device 81O/U)

This protection is used to trip the circuit breaker when the frequency is above or below City’s electric power system’s normal operating level. It is used for generator/turbine protection and backup protection. Generator under frequency relay settings are coordinated with other utilities in the Western Electricity Coordinating Council (WECC) to maintain generation on line during system disturbances. Relays shall not be set for a higher frequency or shorter time delay than specified without prior written approval by City Power Division.
Table 3 – Interconnection System Default Response to Abnormal Frequencies

<table>
<thead>
<tr>
<th>Function</th>
<th>Default Settings</th>
<th>Range of Adjustability</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Frequency (Hz)</td>
<td>Clearing time (s)</td>
</tr>
<tr>
<td>UF1</td>
<td>&lt; 57</td>
<td>0.16</td>
</tr>
<tr>
<td>UF2</td>
<td>&lt; 59.5</td>
<td>2</td>
</tr>
<tr>
<td>OF1</td>
<td>&gt; 60.5</td>
<td>2</td>
</tr>
<tr>
<td>OF2</td>
<td>&gt; 62</td>
<td>0.16</td>
</tr>
</tbody>
</table>

Table 3 is an excerpt from IEEE STD 1547a-2014, Amendment 1. The latest revision of IEEE STD 1547 voltage tables shall be used.

At a minimum, the 60.5 and 59.5 setting shall be used.

For frequency excursions outside these limits the protective device shall automatically initiate a disconnect sequence from the utility system as detailed in ANSI/IEEE STD 1547.

Inverter (PV) frequency control does not operate to the same degree as frequency control with a governor on a classical generator. Inverter (PV) plants shall not actively participate in primary frequency control during under frequency conditions.

Note: Inverters that comply with IEEE STD 929-2000, “Recommended Practice for Utility Interface of Photovoltaic Systems,” and UL 1741, “Inverters, Converters, Controllers, and Interconnection System Equipment for Use with Distributed Energy Resources,” have built-in 81O/U functions. If an inverter lacks these functions, then 81O/U relay protection must be installed.

h. Synchronizing (Device 15/25) and Synch-Check (Device 25)

The application of synchronizing devices attempts to assure that a synchronous generator will parallel with the utility electric system without causing a disturbance to other customers and facilities (present and in the future) connected to the same system. The protection also works to ensure that the generator itself will not be damaged due to an improper parallel action. Synchronous generators and other generators with stand-alone capability must use one of the following methods to synchronize with the City’s electric power system:

- Automatic synchronization (Device 15/25) supervised by a synch-check relay (Device 25) to synchronize with the City’s electric power system.
- Manual synchronization with supervision from a synch-check relay (Device 25) to synchronize with the City’s electric power system.
- Manual synchronization with synchroscope and synch-check (Device 25) relay supervision. (Only allowed for generators with less than 1000kW aggregate nameplate rating.)

The synch-check relay must have all of the following characteristics:

- Less than 500kW – required settings:
  - Slip frequency matching window of 0.3 Hz or less
  - Voltage matching window of ±10 percent or less
  - Phase angle acceptance window of ± 20 degrees or less
• 500-1,500kW – required settings:
  o Slip frequency matching window of 0.2 Hz or less
  o Voltage matching window of ±5 percent or less
  o Phase angle acceptance window of ±15 degrees or less
  o Breaker closure time compensation
• 1,500-2,000kW – required settings:
  o Slip frequency matching window of 0.1 Hz or less
  o Voltage matching window of ±3 percent or less
  o Phase angle acceptance window of ±10 degrees or less
  o Breaker closure time compensation

**Note:** Generators with greater than 1,000kW aggregate nameplate rating must have a synchronizing relay or automatic synchronizer with synch-check supervision.

**Note:** A synch-check function is not needed on induction generators. Unlike synchronous generators, induction generators are not synchronized before paralleling to the electric utility system.

i. **Undervoltage Check (Device 27R)**
   An undervoltage check function, used along with a synch-check relay (25), is used to check for a dead bus and prevents the breaker from closing unless the bus is dead.

   **Note:** This function may not be needed on an induction generator provided the generator will not self-excite when interconnection breaker is open.

j. **Current Unbalance (Device 46)**
   Generation facilities with three-phase generators should be aware that certain conditions on the City’s electric power system may cause negative-sequence currents to flow in the generator. It is the sole responsibility of the generating facility to protect their equipment from excessive negative-sequence currents.

   These unbalanced currents may be caused by open conductors or phase reversals on the City’s electric power system and can subject the generating facility’s generators to a high level of negative-sequence current. This high negative-sequence current results in rapid rotor heating which can damage the generator. Many generator protective relays provide a 46 function to protect against these unbalanced currents.

   **Note:** Often smaller transformers, such as 5MVA or below are used in medium voltage distribution systems, industrial plants, and rural areas. These transformers are most often protected on the load (low) side and only fuses are provided by the local utility on the high side. With an open phase on the high side of a transformer there are cases that the three-phase voltages and currents on the low side could be fairly balanced, particularly in lower loading conditions, such that neither overcurrent nor negative-sequence current elements (46) can pick up a fault. In fact, in lower loading conditions, even as high as 50%, the transformer may continue normal operation for hours and possibly longer with acceptable balanced voltages and currents on the low side while there is an open phase on the high side. Only in higher loading conditions may the protection relays pick up a fault, usually on negative-sequence or sensitive ground overcurrent.
k. **Voltage Unbalance (Device 47)**
   A negative-sequence voltage (unbalance) relay can be installed to provide protection for phase reversals caused by inadvertent “phase swapping” after power restoration.

l. **Ground Fault Sensing Scheme (Device 51G)**
   The ground fault sensing scheme detects City’s electric power system ground faults and trips the generator breaker or the generating facility’s main circuit breaker, thus preventing the facility's generating source from continuously contributing to a ground fault. This scheme must be able to detect faults between the City’s electric power system side of the dedicated transformer and the end of City line. The following transformer connections, along with appropriate relaying equipment, are commonly used to detect system ground faults:
   - System side - grounded wye; Generator side - delta
   - System side - grounded wye; Generator side - wye-tertiary delta

   In general, a ground overcurrent relay (Device 51G) is required to be installed in the step-up transformer neutral (primary voltage side).
   - Ground overcurrent (51G):
     - Pickup: must be set above the City’s electric power system unbalanced current.
     - Time: set above feeder relays and coordinated with the slowest downstream feeder relay ground setting.

   For induction generators, less than 100kW, ground fault detection is not required. Ground fault detection is required for induction generators of 100kW or larger capacity. For synchronous generators aggregating over 40kW, ground fault detection is required.

m. **Phase Directional Overcurrent (Device 67)**
   AC directional overcurrent relay is a device that functions on a desired value of AC overcurrent flowing in a predetermined direction. In some applications, a phase directional overcurrent relay (67) may be used for phase fault back-feed detection. The pickup setting must be set above the level of current normally being supplied by the generating facility to the City’s electric power system and may have to be set low enough to detect faults at the end-of-line at the City’s distribution substation.

n. **Direct Transfer Trip (DTT)**
   A transfer trip may be required on distribution-level interconnections depending on City circuit configuration and loading, as determined by City Power Division. Typically, transfer trip will be required if City Power Division determines that a generation facility cannot detect and trip on the City’s electric power system’s end-of-line faults within an acceptable time frame, or if the generation facility may be capable of keeping a City distribution line energized with the City’s electric power system source disconnected.

   The following are the major protection concerns that could require a DTT to be considered for the PV installation:
   - If the utility breaker opens for any reason (no fault on the feeder) and feeder load is much lower than the PV generation, there will be overvoltage on all three phases regardless of the step-up transformer configuration.
- If based on the SIS, the City customers cannot sustain an overvoltage until it gets cleared by regular system relays or inverter-interfaced built-in protection scheme, DTT should be considered from the utility breaker to the interrupting device at the DR side.

Direct transfer trip (DTT) refers to sending a trip signal from one location to another on the City’s electric power system. For example, this is typically done where a distribution line recloser sends a trip signal to the generating facility’s main utility breaker to ensure that the generating facility does not energize an unintentional island. Various communication channels – including, but not limited to, dedicated cable, spread-spectrum radio, licensed radio, microwave, and fiber optic cable – can be used to provide the signal path.

If other protective means cannot detect an islanded condition and remove a distributed resource from the utility grid, then a DTT may be required. General “rules-of-thumb” for islanding condition:

- DG should be disconnected from the network if abnormal voltage and frequency are detected.
- An island maybe formed when the aggregate size of generating units is equal or larger than “half of the load” of the system at the instant of formation of the island.

DTT timing requirements:
- \( DTT_{\text{TIME}} = \text{COMM}_{\text{TIME}} + \text{DEVICE}_{\text{TIME}} \leq 133\text{ms} \) (8 cycles)
- \( \text{TOTAL}_{\text{TIME}} = DTT_{\text{TIME}} + \text{SUB-RELAY}_{\text{TIME}} \leq 167\text{ms} \) (10 cycles)

Note: A transfer trip scheme can be expensive to install and maintain. The intent of any protection scheme is to ensure faults are cleared quickly to protect devices and ensure safety to personnel and the public. The intent here is to first exhaust all possible protection schemes and then look and consider a transfer trip scheme.

o. **Recloser Operation and Reclose Blocking**

The DR protection and controls must be designed to coordinate with the reclosing practices of the City’s electric power system line protective devices. The generating source must cease to energize the City circuit to which it is connected prior to automatic re-closure of any of the City’s automatic reclosing devices.

Some of the existing City substation feeder circuit reclosers may not be acceptable because their built-in protection features are not suitable for DR interconnection. Further, they may not be capable of interrupting with the sources on both sides of the poles, and their trip-coil rating may be too low. Load-side VT and multifunction relay with deadline logic (voltage supervision) may be required to prevent out-of-sync closing of the DR generator and the utility system during auto or manual or supervisory restoration of the feeder loads.

p. **Inverters Capable of Stand-Alone Operation and Photovoltaics (PV)**

Inverter based systems must demonstrate compliance with all requirements of the latest version of the UL1741, “Standard for Inverters, Converters, Controllers and Interconnection System Equipment for Use with Distributed Energy Resources” by one of the following:

- Use of an inverter(s) meeting the definition of “Certified Equipment” and providing evidence thereof; or
• Testing the system in accordance with the provisions of IEEE STD 1547.1, “IEEE Standard Conformance Test Procedures for Equipment Interconnecting Distributed Resources with Electric Power Systems”.

Inverters capable of stand-alone operation are capable of islanding operation and shall have similar functional requirements as synchronous generators. For units, less than 100kW, usually it is acceptable to have the frequency and voltage functions built into the electronics of the inverter if the set points of these built-in protective functions are tamper-proof and can be easily and reliably tested. These relay functions must receive City Power Division approval before they can be used to interconnect with the City’s electric power system. The total harmonic distortion in the output current of the inverters must meet ANSI/IEEE STD 519 requirements.

9.6 Metering
City will own, install, and maintain revenue meters and associated metering equipment to measure the generation output of the generating facility for all wholesale generation. The generating facility must supply a suitable location for the installation of the metering equipment at the generating facility’s own expense. The cost of the metering equipment, their installation, and their maintenance will be part of the interconnection cost of the generating facility.

The basic configuration will consist of bi-directional metering (delivered and received) net metering at the PCC with the City’s electric power system. In addition, the gross output of the DR may also be metered for certain rates as determined by City Power Division’s Rates, Charges and Fees. Net metering is the difference between the power consumed by the customer and the power delivered by the customer.

Identical DR projects connected at different locations in the City’s electric power system can have widely varying metering requirements and costs. All interconnections require a review and approval of the switchgear drawings showing overall electrical one-lines, physical construction and layout of the metering sections by the City’s metering department.

a. Signage
The customer shall install a sign or placard at the meter indicating the attachment of DR and disconnect. All signs or placards shall be weatherproof, durable, and permanently attached (with screws or rivets) to the meter socket.

9.7 Commissioning Test
a. Commissioning Testing
Commissioning testing will be performed on-site to verify protective settings and functionality. City Power Division has the right to witness the commissioning test, and may also require written certification by the installer describing which tests were performed and their results. Commissioning testing shall include visual inspections of the interconnection equipment and protective settings to confirm compliance with the interconnection requirements. The cost of performing commissioning testing is the responsibility of the generating facility.

When deemed necessary, the DR shall provide City Power Division with copies of test reports for the particular types of protective devices applied before the DR will be allowed to parallel. Where communication-dependent protection is utilized, the communication circuits must be tested and the scheme operation functionally verified prior to release for commercial operation.
b. **Scheduled Testing**

Every five years after commissioning, the DR must submit written test reports for qualified testing to City Power Division demonstrating that the relays are operable and within calibration. City Power Division will not test the DR’s equipment, but reserves the right to witness the testing performed by a qualified testing firm retained by the DR. Circuit breakers shall be tested at least every five years after the initial commissioning tests. The generating facility shall obtain confirmation from service providers or by testing that all communication channels are functional at the same five-year interval as the relay testing.

c. **Testing Qualifications**

Individuals qualified in testing protective equipment (professional engineer, factory-certified technician, or licensed electrician with experience in testing protective equipment) must perform commissioning testing. All protective relay testing shall be done by a NETA certified testing firm.

### 9.8 Generation and Power Conversion Technologies

a. **Synchronous Generators**

The generating unit must meet all applicable American National Standards Institute (ANSI) and Institute of Electrical and Electronic Engineers (IEEE) Standards. The prime mover and the generator must also be able to operate within the nominal range of voltage and frequency excursions that may occur on the City’s electric power system without damage to them. The generating unit must be able to operate through the specified frequency ranges for the time durations in this section to enhance system stability during a system disturbance.

- **Frequency/Speed Control**

  A governor shall be required on the prime mover to enhance system stability. Governor characteristics shall be set to provide a 5 percent droop characteristic. Governors on the prime mover must be operated unrestrained to help regulate the City’s electric power system frequency.

- **Excitation System**

  An excitation system is required to regulate generator output voltage. Excitation systems shall have a minimum ceiling voltage of 150 percent of rated full load field voltage and be classified as a “high initial response excitation system” as defined in IEEE STD 421.1. Static systems shall meet these criteria with 70 percent of generator terminal voltage. The offline generator terminal voltage response shall have an overshoot limited to 20 percent and a bandwidth of at least 0.1 to 4 Hz. However, in no case shall the bandwidth upper limit be less than local mode frequency. Ceiling current shall have a transient time capability equal to or greater than the short time overload capability of the generator. A means shall be provided to quickly remove excitation from the generator field to minimize contributions to faults. The preferred method is to reverse voltage of the generator field to drive the current to zero. Excitation systems shall respond to system disturbances equally in both the buck and boost directions. All bridges that govern excitation response shall be full wave type. Bridges feeding a pilot exciter shall have negative forcing capability.

Under certain conditions, City may grant an exemption for generating facilities that have excitation systems not meeting these requirements. Requests for exemption must be sent to City Power Division.
• **Power Factor Controller**
  The controller must be able to maintain a power factor setting within ±1 percent of the setting at full load at any set point within the capability of the generator. However, control limits shall be between 90 percent lagging and 95 percent leading. Power factor control is typically required for distribution level generator interconnections where the generator is put on a power factor schedule, rather than a voltage schedule.

b. **Asynchronous (Induction) Generators**
Conventional induction generators and other generators with no inherent VAR (reactive power) control capability shall provide an amount of reactive power to maintain power factor between 90 percent lagging and 95 percent leading to maintain the required voltage on the City’s electric power system. They may also be required to follow a City’s specified voltage or VAR schedule on an hourly, daily or seasonal basis, depending on the location of the installation.

**Note:** Double-fed asynchronous machines, also known as double-fed induction generators (DFIGs), are a distinct class of asynchronous generators, employing wound rotor induction machines with static power converters to drive the rotor field currents. The physical rotational speed of the machine can be varied over a wide range, both faster and slower than the synchronous speed. Unlike an ordinary induction machine, a double-fed asynchronous generator can supply or absorb reactive power, which allows power factor or net reactive flow to be easily and quickly controlled. In general, DFIG technology is widely used in wind generation.

• **Excitation**
Conventional induction machines will not be allowed to be self-excited by nearby distribution capacitors, or as the result of capacitive voltage on the distribution network. Entities utilizing conventional induction machines shall provide their own excitation VARs such that the generating facility will not normally demand reactive power from, nor supply reactive power to, the City’s electric power system. Power factor correction capacitors (switched or fixed), power electronics designed to supply a level of reactive capability, or a combination of devices used for excitation shall be provided and installed at the generating facility’s expense. The generating facility shall not disable power factor equipment while induction machines are in operation.

• **Voltage Regulation**
  Speed matching may be by any means such that voltage regulation and voltage flicker are held within tolerance.

For conventional induction generators 100kW and larger a mechanical speed matching relay (Device 15) set to accept mechanical speed within ±5% of 60 Hz. The largest effect on the system of bringing an induction generator to synchronous speed is the voltage drop associated with the magnetizing inrush current.

• **Dynamic Voltage Support**
Wind plants or other induction technologies shall also be able to provide sufficient dynamic voltage support and automatic voltage regulation at the generator excitation system if it is determined that voltage support is required for system safety and reliability. Studies, such as a System Impact Study and associated excitation equipment shall be at the generating facility’s expense.
• **Crowbar**
  In some double-fed induction generators (DFIG), a “crowbar” circuit can be added to the rotor side of the frequency converter to provide overcurrent protection and overvoltage control to the rotor winding. The crowbar circuit limits the transient current in the stator and the rotor to less than 1 per unit (pu) for close-in and multiple-phase faults. It consists of a protection circuit that rapidly short-circuits (or “crowbars”) the supply line if the voltage or current exceeds defined limits.

  c. **Inverters**
  Static power converters (inverters) convert DC electricity into AC electricity and offer additional electronic power conversion. They are sometimes referred to as power conditioning systems. Their fundamental role is to convert DC or non-synchronous AC electricity from a prime mover energy source into a synchronous AC system of voltages that can be smoothly and easily interconnected with the electric power system.

  UL 1741 certified Inverter Technology does not require separate synchronizing equipment (25A) and does not require a synch-check (25) relay.
  - Synchronization or re-synchronization of an inverter to the utility system shall not result in a voltage deviation that exceeds the requirements contained in this document.
  - UL 1741 certified Inverter Technology does not require separate anti-islanding protection, as long as the inverter cannot sustain the system load when disconnected from the utility.

  Inverter technology that is tested to and approved by UL 1741 is acceptable for use for the control functions and protection:
  - Distribution Provider Interaction, UL 1741 – 39
  - DC Isolation, UL 1741 – 40.1
  - Simulated PV Array (Input) Requirements, UL 1741 – 41.2
  - Dielectric Voltage Withstand UL 1741 – 44
  - Power Factor UL 1741 – 45.2.2
  - Harmonic Distortion UL 1741 – 45.4
  - DC Injection UL 1741 – 45.5
  - Distribution Provider Voltage and Frequency Variation UL 1741 – 46.2
  - Reset Delay UL 1741 – 46.2.3
  - Loss of Control Circuit UL 1741 – 46.4
  - Load Transfer UL 1741 – 47.7

9.9 **Example Protection Diagrams**
  - Figure 1: Protection for a Synchronous Generator Interconnected Through a Wye-Wye Transformer
  - Figure 2: Protection for a Synchronous Generator Interconnected Through a Wye-Delta Transformer
  - Figure 3: Protection for a Synchronous Generator Interconnected Through a Delta-Wye Transformer
  - Figure 4: Protection for an Induction Generator Interconnected Through a Wye-Wye Transformer
  - Figure 5: Protection for an Induction Generator Interconnected Through a Wye-Delta Transformer
• Figure 6: Protection for an Induction Generator Interconnected Through a Delta-Wye Transformer
• Figure 7: Protection for Single-Phase Generators
Requirements for Electric Service – Section 9 – Interconnection Requirements for Generating Facilities no Larger than 2MVA

FIGURE 1 - PROTECTION FOR A SYNCHRONOUS GENERATOR INTERCONNECTED THROUGH A WYE-WYE TRANSFORMER

- **ONLY ACTIVE WHEN THE GENERATOR IS PARALLEL WITH THE UTILITY**
- **MINIMUM REQUIREMENTS**
- **SEE IEEE STD 1547 AMENDMENT 1 UPDATES**

Legend:
- [X.X] FOR ATTACHMENT OR ATTACHMENT OF THE SAME TYPE TO THE SAME SYSTEM
- [X.X.X] DENOTES APPLICABLE CLAUSE IN IEEE STD 1547, SEE FIGURE 8

- [1.1] MONITORING
- [1.1.2] ISOLATION DEVICE
- [1.2-1] AREA EPS FAULTS
- [1.2-2] RECLOSING COORDINATION
- [1.2.3] VOLTAGE***
- [1.2.4] FREQUENCY**
- [1.2.6] RECONNECT TO AREA EPS
- [1.4.1] UNINTENTIONAL ISOLATION
- [1.1.2] SYNCHRONIZATION
- [2.5] SYNCH CHECK
- [2.7] UNDervoltage (PREFERRED AUTO-RECLOSE)
- [2.8] UNDervoltage (ALLOWS A TO CLOSE)
- [3.2] POWER (REVERSE OR UNLDER)
- [4.1] NEGATIVE SEQUENCE OR PHASE UNBALANCE OVERCURRENT
- [5.1] TIME OVERCURRENT (PHASE)
- [5.1.2] TIME OVERCURRENT (GROUND)
- [5.1.5] TIME OVERCURRENT (NEUTRAL OR GROUND-RESIDENTIAL)
- **[5.1.5]** TIME OVERCURRENT (VOLTAGE CONTROLLED OR VOLTAGE RESTRICTED)
- [6.9] OVERVOLTAGE
- [6.1] DIRECTIONAL OVERCURRENT (PHASE)
- [6.1.5] OVERVOLTAGE FREQUENCY
- [6.1.5] DISTRIBUTED RESOURCE
- [K.W] KILOWATTS (REAL POWER)
- [K.V] KILOVOLTAMPERES (reactive power)
- [V] VOLT
Requirements for Electric Service – Section 9 – Interconnection Requirements for Generating Facilities no Larger than 2MVA

FIGURE 2 - PROTECTION FOR A SYNCHRONOUS GENERATOR INTERCONNECTED THROUGH A WYE-DELTA TRANSFORMER

NOTES:

1. REQUIRED ONLY IF 27 OPERATING TIME IS TOO SLOW FOR FEEDER FAULT.

2. REVERSE POWER OR UNDER POWER CAN BE USED TO MEET ONE OF FOUR POSSIBLE OPTIONS TO DETECT ISLANDING. SEE [4.6.2].

3. A GROUNDED-WYE-DELTA TRANSFORMER CREATES ADDITIONAL GROUND CURRENT PATHS AND ACTS AS A "GROUND SOURCE" TO THE AREA EPS.

4. OF MAY BE REQUIRED BY THE AREA EPS DEPENDS ON LOCAL CIRCUIT CONFIGURATIONS.

5. INSTANTANEOUS RECL ame (L 0.08 RECLOSE INTERVAL) MAY NOT ALLOW ENOUGH TIME FOR THE OR TO DISCONNECT DURING AREA EPS FAULTS, A RECLOSE INTERVAL OF 1/2 OR MORE MAY BE REQUIRED.

6. FOR SYNCHRONOUS SUPPRESSION MAY BE REQUIRED WHEN CONNECTING TO AN UNGROUNDED DELTA SYSTEM. MAY WANT TO USE OPEN DELTA V&Y IN THIS APPLICATION.


8. MONITORING PROVISIONS REQUIRED FOR OR NOT OR AS A COMPONENT OF OVERLOAD OR MORE. EXCEEDS MONITORING CONNECTION STATUS OF DRL.

9. RECONNECTION AFTER AN AREA EPS DISTURBANCE COULD BE DONE AT A OR B.

LEGEND

[X.2.1] DENOTES APPLICATION CLAUSE IN IEEE STD 1547.

[X.1.1] MONITORING

[X.7.1] ISOLATION DEVICE

[X.2.2] AREA EPS FAULTS

[X.2.3] RECLOSE COORDINATION

[X.2.4] VOLTAGE

[X.2.5] FREQUENCY

[X.2.6] RECONNECTION TO AREA EPS

[X.4.1] UNINTENTIONAL ISLANDING

[X.1.2] SYNCHRONIZATION

25 SYNC CHECK

27 UNDERVOLTAGE

27E UNDERVOLTAGE (ALL. A TO CLOSE)

52 POWER (REVERSE OR UNDER)

45 NEGATIVE SEQUENCE OR PHASE UNBALANCE OVERCURRENT

50 INSTANTANEOUS OVERCURRENT (PHASE)

50N INSTANTANEOUS OVERCURRENT (NEUTRAL OR GROUND-RESISTED)

51 TIME OVERCURRENT (PHASE)

61B TIME OVERCURRENT (GROUND)

61V TIME OVERCURRENT VOLTAGE CONTROLLED OR VOLTAGE RESTRICTION

59 OVERVOLTAGE

67 DIRECTIONAL OVERCURRENT (PHASE)

61SU OVERHUNDER FREQUENCY

DR DISTRIBUTED RESOURCE

10K KWOLTS (REAL POWER)

100A KW-AMPERES (REACTIVE POWER)

350X TRANSFER TRIP (FIRE, NF OR REHER)

V VOLTS
FIGURE 3 - PROTECTION FOR A SYNCHRONOUS GENERATOR INTERCONNECTED THROUGH A DELTA-WYE TRANSFORMER
Requirements for Electric Service – Section 9 – Interconnection Requirements for Generating Facilities no Larger than 2MVA
Requirements for Electric Service – Section 9 – Interconnection Requirements for Generating Facilities no Larger than 2MVA
Requirements for Electric Service – Section 9 – Interconnection Requirements for Generating Facilities no Larger than 2MVA

FIGURE 6 - PROTECTION FOR AN INDUCTION GENERATOR INTERCONNECTED THROUGH A DELTA-WYE TRANSFORMER

NOTES:
1. 34/PHASE SYNCHRONOUS DELTA FOTS COULD BE USED TO FEED A RELAY. THEN RAN AND 2RN WOULD NOT BE REQUIRED.
2. PROVIDES TRANSFORMER PROTECTION BUT DOES NOT PROVIDE AREA EPS PROTECTION FOR AREA EPS FAULTS.
3. IEEE STD 1547 PART 1 GIVES WARNING FOR THE INTERFACE AT THE POINT OF COMMON CURTAINING. OTHER STANDARDS SUCH AS NICE AND THE NESC SHOULD BE CONSULTED FOR PROTECTION OF THE DR.
4. MONITORING PROVISIONS REQUIRED OR UNIT OR DR AGGREGATE OF 250KVA OR MORE. INCLUDES MONITORING CONNECTION STATUS OF DR.
5. RECONNECTION AFTER AN AREA EPS DISTURBANCE COULD BE DONE AT DR OR B.

LEGEND:
[X.X.X] DENOTES APPLICABLE CLAUSE IN IEEE STD 1547. SEE FIGURE 6
[X.X.X] MONITORING
[X.X.X] ISOLATION DEVICE
[X.X.X] AREA EPS FAULTS
[X.X.X] VOLTAGE
[X.X.X] FREQUENCY
[X.X.X] RECONNECTION TO AREA EPS
27 UNDERSCOPE
2RN GROUND UNDERSOPE
50 INSTANTANEOUS OVERCURRENT (PHASE)
50N INSTANTANEOUS OVERCURRENT (NEUTRAL OR GROUND-RESIDUAL)
51 TIME OVERCURRENT (PHASE)
510 TIME OVERCURRENT (GROUND)
51N TIME OVERCURRENT (NEUTRAL OR GROUND-RESIDUAL)
69 OVERVOLTAGE
69N GROUND OVERVOLTAGE
810A OVERRIDER FREQUENCY
DR DISTRIBUTED RESOURCE
KWM KILOWATT (REAL POWER)
KVAR KILOVOLTAMPERES (REACTIVE POWER)
V VOLTS
FIGURE 7 - PROTECTION FOR SINGLE-PHASE GENERATORS
9.10 Example Fault Considerations
These are the types of faults that should be evaluated for the City’s electric power system. Figure 8: using the City’s Circuit 911 as an example:

F1 – Verify infeed from the inverter-interfaced PV does not produce enough infeed to compromise recloser coordination with upstream devices.

F2 – When loss of parallel operation is detected, due to a fault at F2, the DG must separate from the utility system quickly enough to allow the substation breaker to reclose. High-speed reclosing at the City occurs:

- Circuit 911 Substation Feeder Breaker
  - FB 911 (ABB DPU2000)
  - Operations to LOCKOUT: 4
  - Reclose Interval 1: 120 cycles (2s)
  - Reclose Interval 2: 300 cycles (5s)
  - Reclose Interval 1: 600 cycles (10s)

- Line Recloser
  - RECL 911-1 (SEL-351R)
  - Operations to LOCKOUT: 3
  - Reclose Interval 1: 120 cycles (2s)
  - Reclose Interval 2: 900 cycles (15s)

F3 – A fault at F3 could possibly trip the relay on another feeder if no directional element is used.

F4 – A fault at F4 should only be of concern if the upstream recloser was set for “fuse saving” coordination. Without a DG connection, the substation recloser and fuse at fault F4 always see the same fault current and “fuse saving” coordination is established. With a DG connection, the substation recloser now sees less current than the fuse does. This current discrepancy may make the fuse operate faster than the recloser and the recloser-fuse coordination is compromised.

F5 – When a DG is connected downstream of the main feeder protection and a fault occurs at F5, fault current contribution from the DG may reduce the fault current the feeder protection experiences and blind or delay its operation.

F6 – When inverter-interfaced PV are islanded with pole-top capacitors, too much reactive power may be injected to the feeder through the capacitor banks. This condition shall be verified.
9.11 **Interconnection Standard References**


6. UL 1741, “Inverters, Converters, Controllers, and Interconnection System Equipment for Use with Distributed Energy Resources”.

## Requirements for Electric Service

### INDEX

| 1 | 120/208 Volt Service, 25, 30, 84  
120/240 Volt Service, 29, 30 |
| 2 | 277/480 Volt Service, 25, 30, 82, 84, 85  
277/480 Volt Services Greater than 200 Amps, 84  
277/480 Volts up to 200 Amp Services, 82 |

### A

- **Access to Meter Equipment**, 79  
- **Address Labeling of Meters**, 82, 83  
- **Address Posting**, 28, 82, 83  
- Air Conditioners Larger than 5 Tons. See Motors and Three-Phase Equipment  
- Alley Ways, 61  
- American National Standards Institute, 18  
- ANSI. See American National Standards Institute  
- ASTM. See American Society for Testing and Materials  
- Attachment Point, 40, 54  
- Attachment Requirements, 40

### B

- **Backfill**, 37, 58, 59  
- **Brass Tag**, 82, 83  
- **Building Permits**, 24, 29, 30, 35, 37, 38, 39, 40, 41, 52, 82, 83  
- **Building Use Changes**, 77  
- **Burrs**, 37  
- **Bypass Lever**, 30, 82  
- **Bypass Meter Sockets**, 82

### C

- **Cable**  
  - **Cable Handling**, 61  
  - **Cable in Conduit**, 18  
  - **Cable Reel Rolling**, 62  
  - **Cable Reel Storage**, 62  
  - **Dropping Cable Reels**, 61  
  - **Seal Cable Ends**, 62  
  - **Unloading of Cable**, 61  
- **C-DOT.** See Colorado Department of Transportation  
- **CIC.** See Colorado Department of Transportation  
- **City Definition**, 18  
- **Clearances**  
  - **Flammable Gases or Liquids**, 104  
  - **Insufficient Clearances**, 103  
  - **Over Residential Driveways**, 105  
  - **Over Spaces/Ways Subject to Pedestrians/Restricted Travel**, 105  
  - **Overhead Clearances**, 103  
  - **Pad-Mounted Equipment Clearances**, 103  
  - **Service Drops & Drip Loop Clearances**, 105

### D

- **Damage to Metering Equipment**, 79  
- **Definitions & Acronyms**, 18  
- **Demarcation Point**, 18, 35, 53, 81, 82, 83  
- **Disconnects**  
  - **Fire Pump Disconnect Mounting**, 79  
  - **Main Disconnects**, 84, 85  
  - **Service Disconnects**, 39, 40, 79  
  - **Timeframe**, 24  
- **Distributed Resources**, 19  
- **Disturbances.** See Service Quality  
- **DR.** See Distributed Resources

### E

- **Easements**, 35, 42, 52, 53  
- **Electrical Design**, 30, 42, 52, 53  
- **Electrical Service Voltage Standards**, 25  
- **Electronic Load Data**, 77  
- **Energy Management System**, 87  
- **Engineering Deposit**, 42  
- **Equipment Upgrades**, 76  
- **Excavation Requirements**, 58
Requirements for Electric Service – Index

Exemption/Revision Form, 17

F

Fees, 29, 30, 35, 37, 38, 39, 40, 41, 42, 52, 87
Final Grade, 35, 36, 37, 42, 52, 53, 79, 80, 85
Final Inspection, 53
Fire Pumps, 79
Flammable Gases or Liquids, 104
Flicker, 26
Flow Fill, 60
Forward, 22

G

General Requirements, 24
Glass Meter Covers, 78
Grounding
  Ground Bonds, 86
  Ground Faults, 26
  Ground Rods, 29, 31
  Grounding Method, 36
  Gutters, 85

H

Handhole, 29, 36
Harmonic Distortion. See Service Quality
Heat Pumps Larger than 5 Tons. See Motors and Three-Phase Equipment
Hot Tubs, 104
House Meter, 19, 84

I

Important Contacts, 16
Important Documents, 17
Incorrect Labeling, 84
Interconnection, 111
  Interconnection Agreement, 17
  Interconnection Requirements, 112

J

Jaws
  Fifth jaw, 30
  Five-Jaw Meter Socket, 30
  Jaw-Clamping Lever Bypass, 82
Jetline, 59, 60
Jumpered Sockets, 77
Junction Boxes, 36, 81, 85

L

Lever-Operated Bypass, 30
Load Pulse Outputs, 87
Locates, 24, 29, 30, 35, 52
Locks, 77, 84

Lot Corners, 35
Low Voltage, 26

M

Main
  Breaker Enclosures, 78
  Distribution Panels, 84
Meter
  Approved Meter Sockets, 29, 31, 78, 81
  Meter Equipment Approval, 84
  Meter Equipment Mounting, 79
  Meter Locations, 78
  Meter Pedestal, 53, 82
  Meter Pedestals, 81
  Meter Removal, 77
  Meter Socket Lids, 77
  Meter Spades, 82
  Mounting Height, 80
  Prohibited Meter Locations, 79, 80
  Minimum Separation for Multiple Conduits, 58
  Minimum Separation from Other Utilities, 58
  Mis-Wiring, 84
Mobile Home Parks
  Upgrades to Lots Owned by Mobile Home Parks, 42
  Upgrades to Lots Owned Individually, 42
Motor Protection, 26
Motor Start Analysis, 26
Motors and Three-Phase Equipment, 26
Multi-Family Dwellings, 81, 82
Multi-Occupancy Buildings, 84
Multiple Metering, 81, 83, 84

N

National Electric Safety Code, 20
NESC. See National Electric Safety Code

O

Occupational Safety and Health Administration, 58
One-Line Diagram for Current Transformers, 85
One-Line Electrical Drawing, 52
Overhead
  Attachment Point Requirements, 40, 54
  Clearances, 103
  Connection Point Requirements, 40
  Convert Overhead Services to Underground, 25
  Demarcation Point, 40, 53, 83
  Facilities, 25
  New Commercial & Industrial Services, 53
  Primary Metering, 79, 86
  Secondary Lines, 85
  Temporary Pole for Overhead Services, 28

P

Pad-Mounted
  CT Cabinet Approvals, 85
  Equipment Clearances, 103
Parking
Parking Bollards (Posts), 79, 103
Parking Lot Flow Fill Requirements, 61
Parking Lot Lighting, 83
Permanent Structures, 103
Pins, 35
Plat Map, 35
Point of Common Coupling, 20
Potential Transformers, 20, 52, 80, 82, 84, 85, 86, 88
Pre-Construction Meeting, 42, 53
Primary Metering, 79, 86
Protective Enclosures, 79
PT. See Potential Transformers
Pull Boxes, 85
Pulse Metering Request Form, 17
Pulse Output Meters, 87

Raceways, 85
Red Electric Warning Tape, 37
Residential Services
400 Amps & Larger, 81
Development Construction Power, 28
Single Family Homes or Duplexes, 81
Underground-Electrical Substructure, 42
Ring-Type Meter Sockets, 81

Schedule of Rates, Charges and Fees, 17, 87
Seals, 24, 77
Self-Contained Meters, 78, 82
Separately Derived Power Source, 81
Sequence of Meter, Service Entrance and Customer Equipment Connections, 80
Service
Disconnects, 39, 40, 79
Drop, 40, 54
Entrance, 26, 35, 36, 79
Quality, 26
Upgrade, 76
Wire, 81
Service Interruptions. See Service Quality
Single Phasing. See Service Quality
Single-Phase 3-Wire, 240 Volts, 400 Amp Services, 82
Single-Phase Services Greater than 400 Amps, 82, 84
Single-Phasing of Three-Phase Motors, 26
Site Plans, 42
Slip Coupling Riser, 37
Soft Start Device, 26
Solar Photovoltaic Systems Checklist, 17
Solar Thermal Systems Checklist, 17
Spas, 104
Stakes, 35, 36
Steets, 61
Sub-Metering, 83
Sweeps, 36
Swimming Pools, 104
Switchgear, 85, 88

Tanks of Flammable Gases or Liquids, 104
Temporary
277/480 Volt Transformers, 30
Construction Power, 28, 29, 30, 38, 39, 40, 41, 42, 52
Construction Services, 28
Meter, 29, 83
Pole, 28, 31
Structures, 103
Terminations, 28, 29, 30, 35, 37, 38, 39, 40, 41
Three-Phase
120/208 Volt Services, 25
60-Hertz Alternating Current, 25
Motors, 26
Services Greater than 200 Amps, 82
Trenches
Backfill, 59
Bottoms, 58
Commercial Trench Specifications, 58
Cover, 58
Excavation, 58
General, 58
Inspections, 59, 60
Requirements, 36
Variances, 58
Two-Piece Lids, 81

Underground
Clearances, 103
Conductors, 103
Demarcation Point, 83
Facilities, 25
New Services, 25
Piping Street Crossings, 59
Primary Metering, 86
Services, 53, 81
System Extensions, 53
Utility Poles, 30, 80

Vertical Risers, 40, 54
Violations, 36
Voltage Irregularities. See Service Quality

Wall-Mounted Cabinet Requirements, 85
Wall-Mounted CT Cabinets, 80
Warehouse
Hours, 25
Warning Tape, 37
Weatherhead, 28, 40, 53
Wiring Standards, 52
Yard Lights, 24
## Revision Log

<table>
<thead>
<tr>
<th>Date</th>
<th>Revision</th>
</tr>
</thead>
<tbody>
<tr>
<td>10/10/17</td>
<td>Updated drawings 4, 5 &amp; 7 to show the opening in the transformer pad on the correct side towards sidewalk.</td>
</tr>
<tr>
<td>K Reeves</td>
<td>B Reed-Harmel</td>
</tr>
<tr>
<td>10/10/17</td>
<td>Updated drawing 13 with correct description in title block.</td>
</tr>
<tr>
<td>K Reeves</td>
<td>B Reed-Harmel</td>
</tr>
<tr>
<td>10/10/17</td>
<td>Updated window opening size for 45-750kVA transformer pad on drawing 10.</td>
</tr>
<tr>
<td>K Reeves</td>
<td>B Reed-Harmel</td>
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<tr>
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<td>Added Revisions and Updated Standards section on page 12</td>
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<tr>
<td>K Reeves</td>
<td>B Reed-Harmel</td>
</tr>
<tr>
<td>11/30/17</td>
<td>Updated sections 3.3, 3.4 and 2.5 regarding new residential construction</td>
</tr>
<tr>
<td>K Reeves</td>
<td>B Reed-Harmel</td>
</tr>
<tr>
<td>11/30/17</td>
<td>Updated section 4.2 and 4.3 regarding new commercial service.</td>
</tr>
<tr>
<td>K Reeves</td>
<td>B Reed-Harmel</td>
</tr>
<tr>
<td>12/04/17</td>
<td>Updated Section 6.1</td>
</tr>
<tr>
<td>C Burgess</td>
<td>B Reed-Harmel</td>
</tr>
<tr>
<td>12/04/17</td>
<td>Updated Section 2.3</td>
</tr>
<tr>
<td>S Falk</td>
<td>B Reed-Harmel</td>
</tr>
<tr>
<td>12/14/17</td>
<td>Updated Section 5</td>
</tr>
<tr>
<td>C Burgess</td>
<td>B Reed-Harmel</td>
</tr>
<tr>
<td>02/01/18</td>
<td>Revised Drawing 10 – Added note about cable length</td>
</tr>
<tr>
<td>K Reeves</td>
<td>B Reed-Harmel</td>
</tr>
<tr>
<td>02/08/18</td>
<td>Revised Drawing 7</td>
</tr>
<tr>
<td>K Reeves</td>
<td>B Reed-Harmel</td>
</tr>
<tr>
<td>02/08/18</td>
<td>Revised Drawing 23 – Deleted single-phase 120V, 2-Wire 4 terminal</td>
</tr>
<tr>
<td>K Reeves</td>
<td>B Reed-Harmel</td>
</tr>
<tr>
<td>02/12/18</td>
<td>Revised Drawing 22 –Clarification</td>
</tr>
<tr>
<td>K Reeves</td>
<td>B Reed-Harmel</td>
</tr>
<tr>
<td>02/12/18</td>
<td>Updated Section 6.10b to include changes to Table 6-3</td>
</tr>
<tr>
<td>K Reeves</td>
<td>B Reed-Harmel</td>
</tr>
<tr>
<td>02/12/18</td>
<td>Deleted Table 6.3 and replaced it with 6.4</td>
</tr>
<tr>
<td>K Reeves</td>
<td>B Reed-Harmel</td>
</tr>
<tr>
<td>02/12/18</td>
<td>Updated Section 6.10d</td>
</tr>
<tr>
<td>K Reeves</td>
<td>B Reed-Harmel</td>
</tr>
<tr>
<td>02/12/18</td>
<td>Updated Drawing 21- Removed PTs but added notes</td>
</tr>
<tr>
<td>K Reeves</td>
<td>B Reed-Harmel</td>
</tr>
<tr>
<td>02/16/18</td>
<td>Updated Drawing 31- Added note about level working surface.</td>
</tr>
<tr>
<td>K Reeves</td>
<td>B Reed-Harmel</td>
</tr>
<tr>
<td>02/16/18</td>
<td>Updated Drawing 16 and added 16.1 - 16.7 for Vault Details</td>
</tr>
<tr>
<td>K Reeves</td>
<td>B Reed-Harmel</td>
</tr>
<tr>
<td>04/18/18</td>
<td>Updated Interconnection Agreement with terms in Section 9.2</td>
</tr>
<tr>
<td>C Schraeder</td>
<td>B Reed-Harmel</td>
</tr>
<tr>
<td>04/20/18</td>
<td>Removed jetline and replaced it with pull tape.</td>
</tr>
<tr>
<td>K Reeves</td>
<td>B Reed-Harmel</td>
</tr>
<tr>
<td>04/20/18</td>
<td>Renumbered section 6.9 to 6.8</td>
</tr>
<tr>
<td>K Reeves</td>
<td>B Reed-Harmel</td>
</tr>
<tr>
<td>04/20/18</td>
<td>Added cable in conduit length requirements to Section 5.4f</td>
</tr>
<tr>
<td>K Reeves</td>
<td>B Reed-Harmel</td>
</tr>
<tr>
<td>06/04/18</td>
<td>Added note on Drawing 5.1 for test port and tracer wire including bracket</td>
</tr>
<tr>
<td>K Reeves</td>
<td>B Reed-Harmel</td>
</tr>
<tr>
<td>06/04/18</td>
<td>Added Drawing 6.4 for H-Frame Meter Stand Option</td>
</tr>
<tr>
<td>K Reeves</td>
<td>B Reed-Harmel</td>
</tr>
<tr>
<td>06/04/18</td>
<td>Updated Drawing numbers to start with corresponding section number</td>
</tr>
<tr>
<td>K Reeves</td>
<td>B Reed-Harmel</td>
</tr>
<tr>
<td>06/04/18</td>
<td>Added Drawing 5.11 for concrete bases for Streetlights.</td>
</tr>
<tr>
<td>K Reeves</td>
<td>B Reed-Harmel</td>
</tr>
<tr>
<td>06/04/18</td>
<td>Condensed trench drawings from three into one. Renumbered to 5.1</td>
</tr>
<tr>
<td>K Reeves</td>
<td>B Reed-Harmel</td>
</tr>
<tr>
<td>07/12/18</td>
<td>Updated Drawing 5.11 – Added foundation bolts and note about street light being perpendicular to the curb.</td>
</tr>
<tr>
<td>M Padia</td>
<td>B Reed-Harmel</td>
</tr>
<tr>
<td>07/16/18</td>
<td>Changed Drawings 3.2 and 3.3 to HANDHOLE LOCATION and TRANSFORMER PAD LOCATION, respectively.</td>
</tr>
<tr>
<td>M Padia</td>
<td>B Reed-Harmel</td>
</tr>
<tr>
<td>11/26/18</td>
<td>Change d and added definitions to page 17. 3 phase 4 wire 400 amp self-contained. Also added definition for self-contained metering.</td>
</tr>
<tr>
<td>M Sadar</td>
<td>B Reed-Harmel</td>
</tr>
<tr>
<td>11/26/18</td>
<td>Changed commercial temp services to reflect 400 self-contained 3 phase 4 wire 120/208 volt applications. Page 29</td>
</tr>
<tr>
<td>M Sadar</td>
<td>B Reed-Harmel</td>
</tr>
<tr>
<td>11/26/18</td>
<td>Added that we do not allow any K-Base installations. Page 29</td>
</tr>
<tr>
<td>M Sadar</td>
<td>B Reed-Harmel</td>
</tr>
<tr>
<td>11/26/18</td>
<td>Commercial and industrial services now include 3 phase 4 wire 120/208 volt 400 amp self-contained. Page 49 section 4.1 F</td>
</tr>
<tr>
<td>M Sadar</td>
<td>B Reed-Harmel</td>
</tr>
<tr>
<td>11/26/18</td>
<td>Changed drawings on page 36 from 4.5, 7, and8 to 3.2, 3.3, 3.5, and 3.6</td>
</tr>
<tr>
<td>M Sadar</td>
<td>B Reed-Harmel</td>
</tr>
<tr>
<td>11/26/18</td>
<td>Changed drawings on page 78 from No 18 to 6.2</td>
</tr>
<tr>
<td>M Sadar</td>
<td>B Reed-Harmel</td>
</tr>
<tr>
<td>11/26/18</td>
<td>Change to show 3 phase 4 wire 120/208 volt 400 amp service Page 84 and page 82</td>
</tr>
<tr>
<td>M Sadar</td>
<td>B Reed-Harmel</td>
</tr>
<tr>
<td>6/17/19</td>
<td>Updated: Important Contracts, Important Documents, and Foreword</td>
</tr>
<tr>
<td>K O’Field</td>
<td>F Lindauer</td>
</tr>
<tr>
<td>7/8/19</td>
<td>Updated drawings 2.1, 2.2, 3.2, 3.3, 3.5, 3.7, 3.8, 4.2, 5.1 with new clearances and errata corrections</td>
</tr>
<tr>
<td>A Paranto</td>
<td>F Lindauer</td>
</tr>
<tr>
<td>Date</td>
<td>Description</td>
</tr>
<tr>
<td>-----------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>8/22/19</td>
<td>Added definitions: Distribution System and UFER. Alphabetized section.</td>
</tr>
<tr>
<td>10/15/19</td>
<td>Revised sections 2, 3, and 4 to fit a standard format. Corrected errata.</td>
</tr>
<tr>
<td>10/20/19</td>
<td>Added 5.1.n Tracer Wire</td>
</tr>
<tr>
<td>10/25/19</td>
<td>Updated section 5.1 parts d, i, j, k, n</td>
</tr>
<tr>
<td>10/27/19</td>
<td>Added new detail 5.12 Utility Crossings.</td>
</tr>
<tr>
<td>11/14/19</td>
<td>Added a material part to section 5.3 Structural Fill, Flowable Fill and</td>
</tr>
<tr>
<td></td>
<td>Concrete Duct Encasement</td>
</tr>
<tr>
<td>11/22/19</td>
<td>Revised Metering Section 6.1.b, d, e, o; 6.3.d; 6.10.b,f</td>
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