2010 PM/CM 21st Annual Conference

The High-Velocity Edge: Achieving Operational Excellence

ELECTRICAL
Basic Electrical
Rick Miller, PE, LEED® AP
RNM Engineering, Inc.

Vanir Corp.
November 6, 2010
7:15 - 10:45
11:30 - 2:45
Alternate Title:
Alternate Title: Electrical Systems: From a Dream to Reality
Alternate Title:

Electrical Systems:
From a Dream to Reality
-or-

PM/CM
2010 Conference
Alternate Title:

Electrical Systems: From a Dream to Reality

-or-

“From the Utility Pole to the Outlet”®
Electrical Systems - Agenda

• Design Phase
• Construction Phase
• Post Occupancy - (Building Facilities)
• Electrical Equipment
Design Phase

- OPR – Owner’s Project Requirements
- BOD – Basis of Design
- BIM – Building Information Modeling
Design Phase

• Codes
• National Electrical Code (NEC)
• NFPA-70, -70E, -72, -110, -111
• Energy Codes: IECC, ASHRAE/IES, T24
• USGBC - LEED
Design Phase

- Schematic Design - OPR
- Design Development - BOD
- Construction Documents
  - Specifications:
    - AIA, CSI, MasterSpec
  - Drawings:
    - Plans, Diagrams, Schedules
  - Lighting Calculations
  - Calculations: Load, Short Circuit, Arc Flash
Specifications: Electrical

- 260500 COMMON WORK RESULTS FOR ELECTRICAL
- 260513 MEDIUM-VOLTAGE CABLES
- 260519 LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES
- 260519.13 UNDERCARPET ELECTRICAL POWER CABLES
- 260523 CONTROL-VOLTAGE ELECTRICAL POWER CABLES UTP
- 260526 GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS
- 260529 HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS
- 260533 RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS
- 260536 CABLE TRAYS FOR ELECTRICAL SYSTEMS
- 260539 UNDERFLOOR RACEWAYS FOR ELECTRICAL SYSTEMS
- 260543 UNDERGROUND DUCTS AND RACEWAYS FOR ELECTRICAL SYSTEMS
- 260548 VIBRATION AND SEISMIC CONTROLS FOR ELECTRICAL SYSTEMS
- 260553 IDENTIFICATION FOR ELECTRICAL SYSTEMS
- 260573 OVERCURRENT PROTECTIVE DEVICE COORDINATION STUDY
- 260913 ELECTRICAL POWER MONITORING AND CONTROL
- 260923 LIGHTING CONTROL DEVICES
- 260933 CENTRAL DIMMING CONTROLS
- 260936 MODULAR DIMMING CONTROLS
- 260943 NETWORK LIGHTING CONTROLS
- 261116 SECONDARY UNIT SUBSTATIONS
- 261200 MEDIUM-VOLTAGE TRANSFORMERS
- 261300 MEDIUM-VOLTAGE SWITCHGEAR
- 262200 LOW-VOLTAGE TRANSFORMERS
- 262300 LOW-VOLTAGE SWITCHGEAR
Specifications: Electrical

- 262313 PARALLELING LOW-VOLTAGE SWITCHGEAR
- 262413 SWITCHBOARDS
- 262416 PANELBOARDS
- 262419 MOTOR-CONTROL CENTERS
- 262500 ENCLOSED BUS ASSEMBLIES
- 262600 POWER DISTRIBUTION UNITS
- 262713 ELECTRICITY METERING
- 262726 WIRING DEVICES
- 262813 FUSES
- 262816 ENCLOSED SWITCHES AND CIRCUIT BREAKERS
- 262913 ENCLOSED CONTROLLERS
- 262923 VARIABLE-FREQUENCY MOTOR CONTROLLERS
- 263213 ENGINE GENERATORS
- 263323 CENTRAL BATTERY EQUIPMENT
- 263353 STATIC UNINTERRUPTIBLE POWER
- 263533 POWER FACTOR CORRECTION EQUIPMENT
- 263600 TRANSFER SWITCHES
- 264113 LIGHTNING PROTECTION FOR STRUCTURES
- 264200 CATHODIC PROTECTION
- 264313 TRANSIENT-VOLTAGE SUPPRESSION
- 265100 INTERIOR LIGHTING
- 265561 THEATRICAL LIGHTING
- 265600 EXTERIOR LIGHTING
- 265668 EXTERIOR ATHLETIC LIGHTING
Specifications: Format

SECTION 260000 - TITLE OF SPEC SECTION

PART 1 - GENERAL
  1.1 Related Documents
  1.2 Summary
  1.3 Submittals
  1.4 Quality Assurance
  1.5 Coordination

PART 2 - PRODUCTS

PART 3 - EXECUTION
  3.1 Installation
  3.2 Field Quality Control
  3.3 Training
Drawings: Power Plans
Drawings: Lighting Plans
Drawings: Fire Alarm Plans
Drawings: Communication Plans
Drawings: Diagrams
Drawings: Details

Bollard Base Detail

Ground Bus Detail

Conduit Support Method
## Drawings: Schedules

### DIMMING PANEL "GSP13" (277V)

<table>
<thead>
<tr>
<th>DIMMING PANEL</th>
<th>CIRCUIT</th>
<th>Room</th>
<th>Lighting Type</th>
<th>Qty</th>
<th>Load Type</th>
<th>Watts</th>
<th>Total</th>
<th>OUT LOAD</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 1</td>
<td>COURTROOM 2032</td>
<td>24&quot; RECESSED @ DESK</td>
<td>F32</td>
<td>2</td>
<td>Fl-HL-LUMIN</td>
<td>330</td>
<td>1552</td>
<td>1152</td>
</tr>
<tr>
<td>2 2</td>
<td>COURTROOM 2032</td>
<td>24&quot; RECESSED @ SEATING</td>
<td>F32A</td>
<td>2</td>
<td>EYELIGHT</td>
<td>330</td>
<td>686</td>
<td>384</td>
</tr>
<tr>
<td>3 3</td>
<td>COURTROOM 2032</td>
<td>4&quot; LINEAR COVE @ REAR WALL</td>
<td>F32</td>
<td>2</td>
<td>Fl-HL-LUMIN</td>
<td>33</td>
<td>160</td>
<td>185</td>
</tr>
<tr>
<td>4 4</td>
<td>COURTROOM 2052</td>
<td>RECESSED (LOGO)</td>
<td>F56</td>
<td>3</td>
<td>MAG. LV</td>
<td>50</td>
<td>150</td>
<td>150</td>
</tr>
<tr>
<td>5 1</td>
<td>COURTROOM 2052</td>
<td>24&quot; RECESSED @ DESK</td>
<td>F32</td>
<td>3</td>
<td>Fl-HL-LUMIN</td>
<td>330</td>
<td>1152</td>
<td>1152</td>
</tr>
<tr>
<td>6 2</td>
<td>COURTROOM 2052</td>
<td>24&quot; RECESSED @ SEATING</td>
<td>F32A</td>
<td>2</td>
<td>EYELIGHT</td>
<td>330</td>
<td>686</td>
<td>384</td>
</tr>
<tr>
<td>7 3</td>
<td>COURTROOM 2052</td>
<td>4&quot; LINEAR COVE @ REAR WALL</td>
<td>F32</td>
<td>2</td>
<td>Fl-HL-LUMIN</td>
<td>33</td>
<td>160</td>
<td>185</td>
</tr>
<tr>
<td>8 4</td>
<td>COURTROOM 2052</td>
<td>RECESSED (LOGO)</td>
<td>F56</td>
<td>3</td>
<td>MAG. LV</td>
<td>50</td>
<td>150</td>
<td>150</td>
</tr>
<tr>
<td>9</td>
<td>SPARE</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>SPARE</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>SPARE</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>SPARE</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**TOTAL PANEL CONNECTED LOAD (WATTS):** 3742

**TOTAL PANEL CONNECTED LOAD (AMPS ABV 480V, 3 PHASE, 4W x 15):** 4.5

### COPPER FEEDER SCHEDULE A

<table>
<thead>
<tr>
<th>TAG</th>
<th>Amps</th>
<th>Qty</th>
<th>ON</th>
<th>Off</th>
<th>ON</th>
<th>Off</th>
</tr>
</thead>
<tbody>
<tr>
<td>AMP</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>1/2</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>1/2</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>1/2</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>4</td>
<td>1/2</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>5</td>
<td>1/2</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>6</td>
<td>1/2</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>7</td>
<td>1/2</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>8</td>
<td>1/2</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>9</td>
<td>1/2</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>10</td>
<td>1/2</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>11</td>
<td>1/2</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>12</td>
<td>1/2</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>13</td>
<td>1/2</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>14</td>
<td>1/2</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>15</td>
<td>1/2</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>16</td>
<td>1/2</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>

### COPPER FEEDER SCHEDULE B

<table>
<thead>
<tr>
<th>TAG</th>
<th>Amps</th>
<th>Qty</th>
<th>ON</th>
<th>Off</th>
<th>ON</th>
<th>Off</th>
</tr>
</thead>
<tbody>
<tr>
<td>AMP</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>1/2</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>1/2</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>1/2</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>4</td>
<td>1/2</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>5</td>
<td>1/2</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>6</td>
<td>1/2</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>7</td>
<td>1/2</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>8</td>
<td>1/2</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>9</td>
<td>1/2</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>10</td>
<td>1/2</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>11</td>
<td>1/2</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>12</td>
<td>1/2</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>13</td>
<td>1/2</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>14</td>
<td>1/2</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>15</td>
<td>1/2</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>16</td>
<td>1/2</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>

### SYMBOL LIST

- **WIRING D Diagnostics**: Check the wiring and diagnostics for power sources, control circuits, and other electrical systems.
- **WIRING D Diagnostics**: Check the wiring and diagnostics for power sources, control circuits, and other electrical systems.
- **WIRING D Diagnostics**: Check the wiring and diagnostics for power sources, control circuits, and other electrical systems.
- **WIRING D Diagnostics**: Check the wiring and diagnostics for power sources, control circuits, and other electrical systems.
- **WIRING D Diagnostics**: Check the wiring and diagnostics for power sources, control circuits, and other electrical systems.

### SYMBOL LIST

- **WIRING D Diagnostics**: Check the wiring and diagnostics for power sources, control circuits, and other electrical systems.
- **WIRING D Diagnostics**: Check the wiring and diagnostics for power sources, control circuits, and other electrical systems.
- **WIRING D Diagnostics**: Check the wiring and diagnostics for power sources, control circuits, and other electrical systems.
- **WIRING D Diagnostics**: Check the wiring and diagnostics for power sources, control circuits, and other electrical systems.
- **WIRING D Diagnostics**: Check the wiring and diagnostics for power sources, control circuits, and other electrical systems.

### SYMBOL LIST

- **WIRING D Diagnostics**: Check the wiring and diagnostics for power sources, control circuits, and other electrical systems.
- **WIRING D Diagnostics**: Check the wiring and diagnostics for power sources, control circuits, and other electrical systems.
- **WIRING D Diagnostics**: Check the wiring and diagnostics for power sources, control circuits, and other electrical systems.
- **WIRING D Diagnostics**: Check the wiring and diagnostics for power sources, control circuits, and other electrical systems.
- **WIRING D Diagnostics**: Check the wiring and diagnostics for power sources, control circuits, and other electrical systems.

### SYMBOL LIST

- **WIRING D Diagnostics**: Check the wiring and diagnostics for power sources, control circuits, and other electrical systems.
- **WIRING D Diagnostics**: Check the wiring and diagnostics for power sources, control circuits, and other electrical systems.
- **WIRING D Diagnostics**: Check the wiring and diagnostics for power sources, control circuits, and other electrical systems.
- **WIRING D Diagnostics**: Check the wiring and diagnostics for power sources, control circuits, and other electrical systems.
- **WIRING D Diagnostics**: Check the wiring and diagnostics for power sources, control circuits, and other electrical systems.

### SYMBOL LIST

- **WIRING D Diagnostics**: Check the wiring and diagnostics for power sources, control circuits, and other electrical systems.
- **WIRING D Diagnostics**: Check the wiring and diagnostics for power sources, control circuits, and other electrical systems.
- **WIRING D Diagnostics**: Check the wiring and diagnostics for power sources, control circuits, and other electrical systems.
- **WIRING D Diagnostics**: Check the wiring and diagnostics for power sources, control circuits, and other electrical systems.
- **WIRING D Diagnostics**: Check the wiring and diagnostics for power sources, control circuits, and other electrical systems.

### SYMBOL LIST

- **WIRING D Diagnostics**: Check the wiring and diagnostics for power sources, control circuits, and other electrical systems.
- **WIRING D Diagnostics**: Check the wiring and diagnostics for power sources, control circuits, and other electrical systems.
- **WIRING D Diagnostics**: Check the wiring and diagnostics for power sources, control circuits, and other electrical systems.
- **WIRING D Diagnostics**: Check the wiring and diagnostics for power sources, control circuits, and other electrical systems.
- **WIRING D Diagnostics**: Check the wiring and diagnostics for power sources, control circuits, and other electrical systems.
# Drawings: Panel Schedules

**Panel Schedules**

<table>
<thead>
<tr>
<th>CT#</th>
<th>CT#</th>
<th>BKR</th>
<th>CIRCUIT DESCRIPTION</th>
<th>KVA LOAD</th>
<th>CT#</th>
<th>CT#</th>
<th>BKR</th>
<th>CIRCUIT DESCRIPTION</th>
<th>KVA LOAD</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>20/1</td>
<td></td>
<td>BOILER-1, HEATING PUMP P-1, ROOM 009</td>
<td>1.06</td>
<td>2</td>
<td>20/1</td>
<td></td>
<td>RECEPT, ROOM 005</td>
<td>1.44</td>
</tr>
<tr>
<td>2</td>
<td>20/1</td>
<td></td>
<td>BOILER-2, HEATING PUMP P-2, ROOM 009</td>
<td>1.06</td>
<td>4</td>
<td>20/1</td>
<td></td>
<td>RECEPT, ROOM 005</td>
<td>0.72</td>
</tr>
<tr>
<td>5</td>
<td>20/1</td>
<td></td>
<td>PRIMARY CIRC PUMP P-3, ROOM 009</td>
<td>1.66</td>
<td>6</td>
<td>20/1</td>
<td></td>
<td>RECEPT, EF-5, ROOM 008</td>
<td>0.77</td>
</tr>
<tr>
<td>7</td>
<td>20/1</td>
<td></td>
<td>DOMES WATER HEATER P-4, WH-1, ROOM 009</td>
<td>0.628</td>
<td>8</td>
<td>20/1</td>
<td></td>
<td>RECEPT, ROOM 013</td>
<td>1.26</td>
</tr>
<tr>
<td>9</td>
<td>20/1</td>
<td></td>
<td>HYDRONIC CIRC PUMP P-5, ROOM 009</td>
<td>0.528</td>
<td>10</td>
<td>20/1</td>
<td></td>
<td>RECEPT, ROOM 014</td>
<td>0.68</td>
</tr>
<tr>
<td>11</td>
<td>20/1</td>
<td></td>
<td>RECEPT, ROOM 009</td>
<td>0.36</td>
<td>12</td>
<td>20/1</td>
<td></td>
<td>RECEPT, EF-4, ROOM 014, 015</td>
<td>0.28</td>
</tr>
<tr>
<td>13</td>
<td>20/1</td>
<td></td>
<td>RECEPT, ROOM 009</td>
<td>0.9</td>
<td>14</td>
<td>20/1</td>
<td></td>
<td>RECEPT, ROOM 003, 004, 011, 017</td>
<td>0.72</td>
</tr>
<tr>
<td>15</td>
<td>20/1</td>
<td></td>
<td>RECEPT, EF-2, ROOM 018</td>
<td>0.82</td>
<td>16</td>
<td>20/1</td>
<td></td>
<td>SPACE</td>
<td>0</td>
</tr>
<tr>
<td>17</td>
<td>20/1</td>
<td></td>
<td>RECEPT, ROOM 018</td>
<td>0.54</td>
<td>18</td>
<td>20/1</td>
<td></td>
<td>SPACE</td>
<td>0</td>
</tr>
<tr>
<td>19</td>
<td>20/1</td>
<td></td>
<td>DRYER-1, ROOM 019</td>
<td>2.75</td>
<td>20</td>
<td>20/1</td>
<td></td>
<td>SPACE</td>
<td>0</td>
</tr>
<tr>
<td>21</td>
<td></td>
<td></td>
<td></td>
<td>2.75</td>
<td>22</td>
<td>20/1</td>
<td></td>
<td>SPACE</td>
<td>0</td>
</tr>
<tr>
<td>23</td>
<td>20/1</td>
<td></td>
<td>WASHER-1, ROOM 019</td>
<td>1.18</td>
<td>24</td>
<td>20/1</td>
<td></td>
<td>SPACE</td>
<td>0</td>
</tr>
<tr>
<td>25</td>
<td>20/1</td>
<td></td>
<td>RECEPT, RECEPT-TV, ROOM 019</td>
<td>1.26</td>
<td>26</td>
<td>20/1</td>
<td></td>
<td>SPACE</td>
<td>0</td>
</tr>
<tr>
<td>27</td>
<td>20/1</td>
<td></td>
<td>RECEPT, ROOM 019</td>
<td>1.18</td>
<td>28</td>
<td>20/1</td>
<td></td>
<td>SPACE</td>
<td>0</td>
</tr>
<tr>
<td>29</td>
<td>20/1</td>
<td></td>
<td>EF-3, ROOM 016</td>
<td>0.1</td>
<td>30</td>
<td>20/1</td>
<td></td>
<td>SPACE</td>
<td>0</td>
</tr>
<tr>
<td>31</td>
<td>20/1</td>
<td></td>
<td>RECEPT, ROOM 016</td>
<td>0.75</td>
<td>32</td>
<td>20/1</td>
<td></td>
<td>LIGHTS</td>
<td>0</td>
</tr>
<tr>
<td>33</td>
<td>20/1</td>
<td></td>
<td>ELEV, ROOM 012</td>
<td>1.66</td>
<td>34</td>
<td>20/1</td>
<td></td>
<td>LIGHTS</td>
<td>0</td>
</tr>
<tr>
<td>35</td>
<td>20/1</td>
<td></td>
<td>SPACE</td>
<td>0</td>
<td>36</td>
<td>20/1</td>
<td></td>
<td>LIGHTS</td>
<td>0</td>
</tr>
<tr>
<td>37</td>
<td>20/1</td>
<td></td>
<td>SPACE</td>
<td>0</td>
<td>38</td>
<td>20/1</td>
<td></td>
<td>LIGHTS</td>
<td>0</td>
</tr>
<tr>
<td>39</td>
<td>20/1</td>
<td></td>
<td>SPACE</td>
<td>0</td>
<td>40</td>
<td>20/1</td>
<td></td>
<td>LIGHTS</td>
<td>0</td>
</tr>
<tr>
<td>41</td>
<td>20/1</td>
<td></td>
<td>SPACE</td>
<td>0</td>
<td>42</td>
<td>20/1</td>
<td></td>
<td>LIGHTS</td>
<td>0</td>
</tr>
</tbody>
</table>

**Total KVA** 13.6 11

**Lighting**

- **Conn. KVA**: 0
- **Calc. KVA**: 0 (125%)
- **Continuous**: 0
- **Calc. KVA**: 0 (125%)

**Largest Motor**

- **Conn. KVA**: 1.66
- **Calc. KVA**: 2.07 (125%)
- **Heating**: 0
- **Calc. KVA**: 0 (100%)

**Other Motors**

- **Conn. KVA**: 0.97
- **Calc. KVA**: 0.97 (100%)
- **Noncontinuous**: 0.2
- **Calc. KVA**: 0.2 (100%)

**Receptacles**

- **Conn. KVA**: 10.9
- **Calc. KVA**: 10.5 (50%-10)
- **Kitchen Equip**: 0
- **Calc. KVA**: 0 (N/A)

**Noncoin/Diverse**

- **Conn. KVA**: 6.68
- **Calc. KVA**: 0 (0%)

**Total KVA**

- **Conn. KVA**: 24.5
- **Calc. KVA**: 17.8

**Balanced Phase Amps**: 74.2
# Short Circuit Calculations

---

**UNBALANCED FAULT REPORT**

*FOR APPLICATION OF LOW VOLTAGE BREAKERS*

**PRE FAULT VOLTAGE:** 1.0000

**MODEL TRANSFORMER TAPS:** NO

<table>
<thead>
<tr>
<th>LOCATION</th>
<th>PHASE</th>
<th>VOLTAGE DUTIES</th>
<th>EQUIVALENT (PU)</th>
<th>ASYM. KA AT 0.5 CYCLES</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3 PHASE</td>
<td>5.00</td>
<td>200</td>
<td>LN/LN/GND</td>
</tr>
<tr>
<td>SUB 2A</td>
<td>3 PHASE</td>
<td>5.00</td>
<td>200</td>
<td>LN/LN/GND</td>
</tr>
<tr>
<td>SUB 2B</td>
<td>3 PHASE</td>
<td>5.00</td>
<td>200</td>
<td>LN/LN/GND</td>
</tr>
<tr>
<td>SUB 3A</td>
<td>3 PHASE</td>
<td>5.00</td>
<td>200</td>
<td>LN/LN/GND</td>
</tr>
<tr>
<td>SUB 3B</td>
<td>3 PHASE</td>
<td>5.00</td>
<td>200</td>
<td>LN/LN/GND</td>
</tr>
<tr>
<td>SUB 4A</td>
<td>3 PHASE</td>
<td>5.00</td>
<td>200</td>
<td>LN/LN/GND</td>
</tr>
</tbody>
</table>
Overcurrent Coordination
# Arc Flash Analysis

## Table 6.1 – Arc-Flash Analysis Summary Table

<table>
<thead>
<tr>
<th>Bus Name</th>
<th>Protective Device Name</th>
<th>Bus kV</th>
<th>Bus Bolted Fault (kA)</th>
<th>Prot Dev Bolted Fault (kA)</th>
<th>Prot Dev Arcing Fault (kA)</th>
<th>Trip/Delay Time (sec)</th>
<th>Breaker Opening Time (sec)</th>
<th>Gnd Equip Type</th>
<th>Gap (mm)</th>
<th>Arc Flash Boundary (in)</th>
<th>Working Distance (in)</th>
<th>Incident Energy (cal/cm²)</th>
<th>Hazard Risk Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALT-1 L</td>
<td>ATS-1 E FDR</td>
<td>0.46</td>
<td>17.67</td>
<td>17.67</td>
<td>10.67</td>
<td>0.017</td>
<td>0</td>
<td>Yes</td>
<td>PNL</td>
<td>25</td>
<td>12</td>
<td>18</td>
<td>0.59</td>
</tr>
<tr>
<td>ATS-17 L</td>
<td>5-15 FDR</td>
<td>0.45</td>
<td>4.1</td>
<td>4.1</td>
<td>2.6</td>
<td>0.32</td>
<td>0</td>
<td>Yes</td>
<td>PNL</td>
<td>25</td>
<td>28</td>
<td>18</td>
<td>2.5</td>
</tr>
<tr>
<td>ATS-8 L</td>
<td>6-8 FDR</td>
<td>0.45</td>
<td>15.95</td>
<td>15.95</td>
<td>9.77</td>
<td>0.05</td>
<td>0</td>
<td>Yes</td>
<td>PNL</td>
<td>25</td>
<td>22</td>
<td>18</td>
<td>1.6</td>
</tr>
<tr>
<td>ATS-1 L</td>
<td>2-15 FDR</td>
<td>0.45</td>
<td>12.19</td>
<td>12.19</td>
<td>7.76</td>
<td>2</td>
<td>0</td>
<td>Yes</td>
<td>PNL</td>
<td>25</td>
<td>101</td>
<td>18</td>
<td>20</td>
</tr>
<tr>
<td>ATS-10 L</td>
<td>7-9 FDR</td>
<td>0.45</td>
<td>19.2</td>
<td>19.85</td>
<td>11.24</td>
<td>0.051</td>
<td>0</td>
<td>Yes</td>
<td>PNL</td>
<td>25</td>
<td>24</td>
<td>18</td>
<td>1.9</td>
</tr>
<tr>
<td>ATS-11 L</td>
<td>7-17 FDR</td>
<td>0.45</td>
<td>4.26</td>
<td>4.26</td>
<td>3.16</td>
<td>2</td>
<td>0</td>
<td>Yes</td>
<td>PNL</td>
<td>25</td>
<td>66</td>
<td>18</td>
<td>19</td>
</tr>
<tr>
<td>ATS-12 L</td>
<td>7-12 FDR</td>
<td>0.45</td>
<td>13.18</td>
<td>11.81</td>
<td>7.32</td>
<td>2</td>
<td>0</td>
<td>Yes</td>
<td>PNL</td>
<td>25</td>
<td>101</td>
<td>18</td>
<td>20</td>
</tr>
<tr>
<td>ATS-13 L</td>
<td>7-8 FDR</td>
<td>0.45</td>
<td>14.56</td>
<td>13.01</td>
<td>8.08</td>
<td>2</td>
<td>0</td>
<td>Yes</td>
<td>PNL</td>
<td>25</td>
<td>103</td>
<td>18</td>
<td>21</td>
</tr>
<tr>
<td>ATS-14 L</td>
<td>7-13 FDR</td>
<td>0.45</td>
<td>4.22</td>
<td>4.22</td>
<td>3.14</td>
<td>0.5</td>
<td>0</td>
<td>Yes</td>
<td>PNL</td>
<td>25</td>
<td>42</td>
<td>18</td>
<td>4.7</td>
</tr>
<tr>
<td>ATS-18 N DISC</td>
<td>2-9 FDR</td>
<td>0.45</td>
<td>11.85</td>
<td>11.85</td>
<td>7.68</td>
<td>2</td>
<td>0</td>
<td>Yes</td>
<td>PNL</td>
<td>25</td>
<td>101</td>
<td>18</td>
<td>20</td>
</tr>
<tr>
<td>ATS-19 L</td>
<td>2-16 FDR</td>
<td>0.45</td>
<td>4.25</td>
<td>4.25</td>
<td>2.66</td>
<td>0.23</td>
<td>0</td>
<td>Yes</td>
<td>PNL</td>
<td>25</td>
<td>23</td>
<td>18</td>
<td>1.8</td>
</tr>
<tr>
<td>ATS-19 N FDR BOX</td>
<td>SUB 2B FDR</td>
<td>0.45</td>
<td>12.45</td>
<td>12.18</td>
<td>7.74</td>
<td>2</td>
<td>0</td>
<td>Yes</td>
<td>PNL</td>
<td>25</td>
<td>102</td>
<td>18</td>
<td>21</td>
</tr>
<tr>
<td>ATS-20 E FDR BOX</td>
<td>GEN BKR</td>
<td>0.45</td>
<td>17.23</td>
<td>9.12</td>
<td>5.52</td>
<td>2</td>
<td>0</td>
<td>Yes</td>
<td>PNL</td>
<td>25</td>
<td>108</td>
<td>18</td>
<td>22</td>
</tr>
<tr>
<td>ATS-3 L</td>
<td>3-13 FDR96</td>
<td>0.45</td>
<td>4.22</td>
<td>4.22</td>
<td>3.14</td>
<td>2</td>
<td>0</td>
<td>Yes</td>
<td>PNL</td>
<td>25</td>
<td>97</td>
<td>18</td>
<td>19</td>
</tr>
<tr>
<td>ATS-3 N FDR BOX</td>
<td>SUB 3B FDR</td>
<td>0.45</td>
<td>12.15</td>
<td>12.15</td>
<td>7.75</td>
<td>2</td>
<td>0</td>
<td>Yes</td>
<td>PNL</td>
<td>25</td>
<td>102</td>
<td>18</td>
<td>20</td>
</tr>
<tr>
<td>ATS-4 L</td>
<td>4-11 FDR</td>
<td>0.45</td>
<td>4.13</td>
<td>4.13</td>
<td>3.08</td>
<td>2</td>
<td>0</td>
<td>Yes</td>
<td>PNL</td>
<td>25</td>
<td>96</td>
<td>18</td>
<td>19</td>
</tr>
<tr>
<td>ATS-5 L</td>
<td>4-9 FDR</td>
<td>0.45</td>
<td>18.22</td>
<td>17.2</td>
<td>10.34</td>
<td>0.052</td>
<td>0</td>
<td>Yes</td>
<td>PNL</td>
<td>25</td>
<td>24</td>
<td>18</td>
<td>1.9</td>
</tr>
<tr>
<td>ATS-6 L</td>
<td>5-14 FDR</td>
<td>0.45</td>
<td>4.24</td>
<td>4.24</td>
<td>3.15</td>
<td>2</td>
<td>0</td>
<td>Yes</td>
<td>PNL</td>
<td>25</td>
<td>97</td>
<td>18</td>
<td>19</td>
</tr>
<tr>
<td>ATS-7 L</td>
<td>5-9 FDR</td>
<td>0.45</td>
<td>4.23</td>
<td>4.23</td>
<td>3.15</td>
<td>2</td>
<td>0</td>
<td>Yes</td>
<td>PNL</td>
<td>25</td>
<td>97</td>
<td>18</td>
<td>19</td>
</tr>
<tr>
<td>ATS-9 L</td>
<td>7-14 FDR</td>
<td>0.45</td>
<td>19.39</td>
<td>19.39</td>
<td>11.55</td>
<td>0.05</td>
<td>0</td>
<td>Yes</td>
<td>PNL</td>
<td>25</td>
<td>24</td>
<td>18</td>
<td>1.9</td>
</tr>
<tr>
<td>BASEMENT SHUTTLE 21</td>
<td>2-11 FDR</td>
<td>0.45</td>
<td>13.02</td>
<td>13.02</td>
<td>8.22</td>
<td>0.05</td>
<td>0</td>
<td>Yes</td>
<td>PNL</td>
<td>25</td>
<td>19</td>
<td>18</td>
<td>1.3</td>
</tr>
<tr>
<td>BASEMENT SHUTTLE 24/25</td>
<td>7-14 FDR</td>
<td>0.45</td>
<td>2.67</td>
<td>2.67</td>
<td>2.12</td>
<td>0.056</td>
<td>0</td>
<td>Yes</td>
<td>PNL</td>
<td>25</td>
<td>8</td>
<td>18</td>
<td>0.35</td>
</tr>
<tr>
<td>BUS-1A</td>
<td>Y1108 PHASE</td>
<td>12.00</td>
<td>32.19</td>
<td>32.04</td>
<td>30.48</td>
<td>0.322</td>
<td>0.05</td>
<td>Yes</td>
<td>SWG</td>
<td>153</td>
<td>505</td>
<td>36</td>
<td>16</td>
</tr>
</tbody>
</table>
Arc Flash Warning Labels

**CAUTION**

Arc Flash and Shock Hazard
Appropriate PPE Required

31 inches | Flash Hazard Boundary
1.0 cal/cm² | Flash Hazard at 36 inches

Category 0

12470 VAC | Shock Hazard when cover is removed
2 | Class Glove with Leather Protectors
60 inches | Limited Approach (Fixed Circuit)
26 inches | Restricted Approach
7 inches | Prohibited Approach

Location: PME-9-4

Warning: Changes in equipment settings, system configuration, or utility service will invalidate the calculated values and PPE requirements

**WARNING**

Arc Flash and Shock Hazard
Appropriate PPE Required

127 inches | Flash Hazard Boundary
29 cal/cm² | Flash Hazard at 18 inches

Category 4

480 VAC | Shock Hazard when cover is removed
00 | Class Glove with Leather Protectors
42 inches | Limited Approach (Fixed Circuit)
12 inches | Restricted Approach
1 inches | Prohibited Approach

Location: MAIN TB1CEMS04 E

Warning: Changes in equipment settings, system configuration, or utility service will invalidate the calculated values and PPE requirements

**DANGER**

ENERGIZED WORK PROHIBITED

319 inches | Flash Hazard Boundary
134 cal/cm² | Flash Hazard at 18 inches

Dangerous!

480 VAC | Shock Hazard when cover is removed
00 | Class Glove with Leather Protectors
42 inches | Limited Approach (Fixed Circuit)
12 inches | Restricted Approach
1 inches | Prohibited Approach

Location: MAIN TB1CEMS05

Warning: Changes in equipment settings, system configuration, or utility service will invalidate the calculated values and PPE requirements
LEED® Design Process

• LEED
  – Outdoor Lighting
  – Indoor Lighting Energy (daylight harvesting)
  – Daylight Factor
  – Views

• LEED Certification Levels:
  – Certified  40–49 points
  – Silver      50–59 points
  – Gold        60–79 points
  – Platinum    80 points and up
Construction Phase

• Skyer (Prolog, BuzzSaw)
• BIM
• Product Submittals
• Requests for Information
• Change Orders
• Observations vs Inspections
  – Observations by the Designers
  – Inspections by AHJ
Construction Process

• Prepare Bid & Cost Estimate
• Assemble Team (Management & Labor)
• Order Products
• Layout Work
  – Use BIM
  – Coordinate with General, Mechanical, Others
• Install Products & Make Connections
• Test Installation
  – by EC or Manufacturer or Third Party
LEED® Commissioning

• Fundamental Cx is a Prerequisite
  – for Electrical, this means Lighting Control

• Enhanced Cx is Optional (worth 2 points)
  – Lighting Control is still required
  – Electrical Distribution, Generators, etc

• Materials
LEED® CX Process

- Design reviews
- Product reviews
- Construction reviews
- Installation Verification
- Prefunctional Check (Start up)
- Function Performance Test
Post Occupancy

- Facility Management
- BIM
- Remodeling
- BOMA Documentation
Electrical Equipment

• Utility Transformer
• Switchgear
• Switchboard
• Meter Sockets
• Distribution Panelboard
• Panelboard
• Motor Control Center
• Disconnect Switch
Electrical Equipment

- Busway, Pipe and Wire
- Transformers
- Generator, UPS, PV, Fuel Cell, Battery
- Computer Rooms
- Communication Systems
- Lighting
- Lighting Controls
- Wiring Devices
One Line - 12KV or 4160V

Utility - 69KV

MV SWGR

MV MCC

MV Motors

MV PARGR

G

G
One Line - 480/277V

PV
INV

480V SWBD

MCC
UP

T
Utility

ATS

G

Disc Sw

M
M

Computer

DP
PP
T
LP
EM
Utility Transformer

Utility - 69KV

T

MV SWGR

T

MV MCC

M M

MV Motors

G G

MV PARGR
Utility Transformer

- Compartment Pad Mount
- Pole Mount
Utility Transformer

- Compartment Pad Mount
- Pole Mount
Switchgear

Utility - 69KV

MV SWGR

MV MCC

T

MV Motors

G G

MV PARGR

M M
Switchgear

- 5’,6’D x 90”H x ??’L
- 480V, 5kV, 15kV
- Drawout CB
- Meters & Relays
Switchgear
Switchboard

PV

INV

T

Utility

480V SWBD

MCC

UPS

DP

ATS

PP

T

LP

EM

Disc Sw

M

M

Computer
Switchboard

• 12”, 24”, 36”D x 90”H x ??”L
• Voltages:
  – 120/240V, 1P, 3W
  – 208Y/120V, 3P, 4W
  – 480Y/277V, 3P, 4W
  – 480V, 3P, 3W
• Current: 400A-2000A
• CB or Sw&Fu
Motor Control Center

- Grouped motor starters
- 90”H x 20”D x 20”W per section
- “Buckets”
- VFDs
Motor Control Center

- Grouped motor starters
- 90”H x 20”D x 20”W per section
- “Buckets”
- VFDs
Disconnect Switch

Utility

PV

INV

480V SWBD

MCC

UPS

Disc Sw

M

M

Computer

M

M

DP

PP

T

LP

ATS

EM

G
Disconnect Switch

- Voltage rating: Normal Duty 250V
  Heavy Duty 600V (480V)
- Current rating: 30A, 60A, 100A, 200A, 400A, 600A, 800A, 1000A
- Switch and Fuse
- Non-fused (switch only)
- Safety interlock
Disconnect Switch

- Voltage rating: Normal Duty 250V
  Heavy Duty 600V (480V)
- Current rating: 30A, 60A, 100A, 200A,
  400A, 600A, 800A, 1000A
- Switch and Fuse
- Non-fused (switch only)
- Safety interlock
Distribution Panelboard

- 30-42"W x 6-10"D x ??"H
- Voltages:
  - 208Y/120V, 3P, 4W
  - 480Y/277V, 3P, 4W
  - 480V, 3P, 3W
- Current: 400A-1000A
- Main CB or MLO
- CB or Sw&Fu
Panelboard

• 20”W x 6”D x ??”H
• Voltages:
  – 120/240V, 1P, 3W
  – 208Y/120V, 3P, 4W
  – 480Y/277V, 3P, 4W
  – 480V, 3P, 3W
• Current: 100A-400A
• Main CB or MLO
Panelboard

• 20”W x 6”D x ??”H
• Voltages:
  – 120/240V, 1P, 3W
  – 208Y/120V, 3P, 4W
  – 480Y/277V, 3P, 4W
  – 480V, 3P, 3W
• Current: 100A-400A
• Main CB or MLO
Pipe and Wire

• Conduit
  – Rigid, Intermediate IMC, Tubing EMT, Flex, Liquidtight, PVC, Wireway (Gutter, Trough)

• Wire
  – Copper, Aluminum
  – Size: #14 AWG, #1, even larger 750kcmil
  – Temperature Rating: 60C, 75C,
  – Voltage rating: 300V, 600V, 5kV, 15kV,…
Transformers

Utility

PV

INV

480V SWBD

MCC

UPS

Disc Sw

M

M

Computer

DP

PP

T

LP

ATS

EM

G
Transformers

- Power transformers (liquid filled)
- Dry-Type transformers
- Efficiency Rating
- Power Rating
- Voltages
Transformers

- Power transformers (liquid filled)
- Dry-Type transformers
- Efficiency Rating
- Power Rating
- Voltages
Power Producers

- Generator
- Photovoltaic (PV)
- Fuel Cell
- Battery
Generator

- Fuel - Diesel, Natural Gas
- Combustion Air
- Cooling Air
- Muffler
- Exhaust
- Vibration
- Controls
Generator

• Environmental Enclosure
• Sound Enclosure
• Fuel Tank
Photovoltaic (PV)

Utility

PV

INV

480V SWBD

MCC

UPS

Computer

Disc Sw

M

M

MCC

UPS

Computer

Disc Sw

M

M

Utility

T

480V SWBD

G

PP

T

LP

EM

ATS
Photovoltaic (PV)

- Utility Permission
- Solar Panel
- DC Disconnects
- Inverter
- AC Disconnect
- Labels
Fuel Cell

- Natural Gas input
- Electricity output
- Heat output
Computer Rooms

- Uninterruptible Power Supply (UPS)
- Power Distribution Unit (PDU)
- Emergency Power Off (EPO)
- Fire Protection
- Fire Alarm
Computer Rooms

• Uninterruptible Power Supply (UPS)
• Power Distribution Unit (PDU)
• Emergency Power Off (EPO)
• Fire Protection
• Fire Alarm
Busway
What’s a bus weigh?
What’s a bus weigh?
Busway (aka Bus Duct)

- Bus bars, insulated and enclosed
- Current rating: 100A - 3000A
- 10ft lengths (aka ‘stick’)
- Special fittings
Meter Sockets

- Multiple Residential or Commercial
- Voltages:
  - 120/240V, 1P, 3W
  - 208Y/120V, 3P, 4W
  - 480Y/277V, 3P, 4W
  - 480V, 3P, 3W
- Current: 100A-320A
- 1∅ sockets on 3∅
Lighting

• Fixtures
Lamps & Ballasts

• Lamps
  – Incandescent: Bye Bye
  – Fluorescent: Colors
  – HID: CMH, PS
  – LED: Hello

• Ballasts
  – Electronic: IS, PS
  – Dimming: Step, Cont.
    2W, 3W, 0-10VDC, DALI
Lighting Controls

Utility

MSB

Busway

LCP

LP

DP

RP

TP

OS

Ballast

S

M
Lighting Controls

- Occupancy Sensors
- Daylight Sensors
- Architectural Dimming
- Central vs Distributed
- Relays
- Digital
- Wireless
Wiring Devices

- Switches
- Receptacles
- Plugs
- Wallplates
In Conclusion

• From a Dream to Reality
  The Design Process

• From the Utility Pole to the Outlet
  The Construction Process
From the Utility Pole to the Outlet
Credits

- Advanced Transformer - Philips
- AIA-MasterSpec
- Bloom Energy
- Cummins/Onan
- General Electric
- HOK, Architects & Engineers
- Hubbell

- Leviton
- Rick Miller
- Smith, Fause McDonald Inc
- Southwest Energy Systems
- The Engineering Enterprise
- Watt Stopper
The End