SECTION 16010 - ELECTRICAL

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1.0 SCOPE

This section covers general electrical standards that are applicable for all electrical and instrument design, construction and installation for the City of Portland (COP), Bureau of Environmental Services (BES), Wastewater Group (WG), including the Columbia Blvd. Wastewater Treatment Plant, Tryon Creek Wastewater Treatment Plant and the Wastewater Pump Stations maintained by the Group.

These standards are a minimum and are in no way to be considered the solution for all installations. If a conflict occurs between these standards and the agency having authority over the enforcement of the applicable laws, rules, codes, etc., it shall be the responsibility of the contractor to bring it to the attention of the Project Engineer for resolution.

The requirements of this section apply to the sections listed below unless specially exempted or superseded by another requirement in that section.

SECTION 16050 - BASIC ELECTRICAL MATERIALS AND METHODS
SECTION 16150 - MOTORS
SECTION 16400 - SERVICE AND DISTRIBUTION
SECTION 16480 - MOTOR CONTROL
SECTION 16500 - LIGHTING
SECTION 16660 - POWER GENERATION
SECTION 16700 - COMMUNICATIONS
SECTION 16910 - CONTROLS
SECTION 17100 - INSTRUMENTATION

1.1 EFFECTIVE CODES

All electrical work shall meet the requirements of the NEC Code as accepted and revised by the State of Oregon and by any other codes or standard practices in effect at the job site, including but not limited to the following:

1. American National Standards Institute (ANSI)

2. American Society for Testing and Materials (ASTM)
3. Code of the City Of Portland (COP)
4. Illuminating Engineering society (IES)
5. Institute of Electrical and Electronics Engineers (IEEE)
6. Instrument Society of America (ISA)
7. Insulated Cable Engineers Association (ICEA)
8. Life Safety Code (NFPA-101-B85)
9. Local Utility Company(PGE/PPL)
10. National Electrical Contractor's Association (NECA) Standard of Installation
11. National Electrical Manufacturer's Association (NEMA)
12. National Electrical Safety Code (NESC)
13. National Electrical Testing Association (NETA)
14. Occupational Safety and Health Act (OSHA)
15. OAR 479.610[1]
16. State Fire Marshal[2]

Code compliance required by law is mandatory.

1.2 RESOLVING CONFLICTS

Wherever the requirements of the Specifications or Drawings exceed the requirements of these Specifications, the Drawings and specifications govern. Conflicts, if any, that may exist between the above items will be resolved at the discretion of the City's Engineer (herein referred to as the Engineer).

In conjunction with the Project Engineer, the Contractor shall identify conflicts, with any and all applicable standards, to the Engineer who will provide resolution. Certain methods and materials for the project will require special approval and it is the Contractor's responsibility to prepare and submit to **all approving authorities;** additional clarifying details, test data, methods and materials as needed to secure the required approval and resolve the conflict(s).

Any correction to work, materials or equipment needed to meet the requirements of this section or the sections listed above, shall be completed by the party in error in a timely manner and at that party's expense.

1.3 RESPONSIBILITY TO BE FAMILIAR WITH THESE STANDARDS

Contractors and other persons performing work must become familiar with this section, the sections mentioned above, and any other division that applies to the work they are providing.

2.0 EQUIPMENT AND MATERIALS PROVIDED

[1] Rev.2003
[2] Rev.2003

2.1 EQUIPMENT QUALITY AND CONDITION

Unless otherwise indicated; provide all first quality, new materials and equipment, in first class condition (free from any contamination or defects), and suitable for the space and environment provided.

2.2 EQUIPMENT MANUFACTURERS

Unless it is stated that a particular manufacturer or model number shall be used, the use of a manufacturer's name and model or catalog number is for the purpose of establishing the standard of quality and general configuration desired only.

Materials shall be rated by the manufacturer as suitable for the intended application. Unless otherwise indicated, provide materials and equipment, which are the standard products of manufacturers regularly engaged in the production of such materials and equipment. Provide the manufacturers latest standard design that conforms to these Specifications. Equipment and materials provided must be in current production, with no plans by the manufacturer to stop production of the product.

Material provided of the same type of classification and used for the same purpose shall be of the same manufacturer. Like items of materials provided shall be the end products of one manufacturer in order to achieve standardization for appearance, maintenance, and replacement parts. If this is not feasible, component parts of materials or equipment may be products of a different manufacturer, however written approval of the engineer and either E & I Planner or the E & I Supervisor must be obtained[3].

2.3 EQUIPMENT AND MATERIAL LISTINGS AND RATINGS

All electrical materials and equipment shall bear the label of, or be listed by, an approved testing agency such as Underwriters' Laboratory, Inc. (UL).

2.4 FIXTURE CONNECTIONS

Electrical equipment shall provide for fixture connections.

2.5 CARE OF EQUIPMENT AND MATERIAL PRIOR TO INSTALLATION

Equipment and material shall be protected from dust, water, moisture and damage. Temporary space heaters shall be provided (by the contractor), when required, and energized to prevent condensation for motor control centers (bottom of vertical section), distribution panels, motors, etc. All equipment shall be covered with heavy-gauge polyethylene sheeting or canvas to protect the equipment from dust, corrosion and moisture. All equipment and materials shall be stored in an indoor, heated area and protected in accordance with the manufacturer’s recommendations.

[3] Rev. 2003

2.6 EQUIPMENT AND DEVICE IDENTIFICATION

Permanent identification labels shall be provided for all electrical equipment that has a designation on prints. In addition all cabinets, boxes, raceways, and MCC's will have permanent identification labels. Labels will not be placed obscuring any information printed or labeled on the equipment. For removable equipment, such as motors, labels will be placed near the equipment on a permanent cabinet, structure, or device made expressly for display of the label and so that when an instrument or device is removed, the label remains in place (not attached to the device.). Position the label so that it is readily visible and that it is obvious what equipment the label describes.

2.6.1 INFORMATION ON LABELS

The specific information that is to be on the label will be listed in the section that covers that equipment or material. In general, the information on the label or tag will fall into four categories:

1. Equipment-specific items.
2. Safety warning(s) and instructions.
   - If power is supplied to equipment, or if the equipment powers other equipment, the source circuit and/or destination equipment information shall be included on the label.
3. Equipment or Instrument tag numbers from the prints or specifications.
4. MCC/Section/Bucket number(s).
   - If the bucket/equipment receives power from other equipment, the source circuit and equipment information shall be included on label.

2.6.2 MATERIALS USED FOR LABELS

Labels will be plastic self-adhesive with plain block letters on the following backgrounds: White for the Computer Maintenance (COMA) system equipment number, Blue for component number, White for related equipment tag, Red for foreign voltage, and Yellow for bucket identification. The colors of the letters are as follows: Blue for COMA equipment number, White for component number, Black for related equipment tag, White for foreign voltage, and Black for bucket number. More durable materials may be used for locations exposed to the elements such as engraved laminated plastic/phenolic with White letters on a Black background. Nameplate sizes will vary as appropriate for the application. (Dymo Tape embossed-style labels are not acceptable, but printed plastic self-adhering labels may be used on suitable surfaces if applied in a craftsperson like fashion.)

The Wastewater Group standard tag material is supplied by the Brady Co., Labelizer Plus Industrial Labeling System using the following tape/color/size combinations:

- *White lettering on blue tape, 4", 2.25", 1.25", 1/2"*
- *Black lettering on white tape, 1.25", 1/2"*

- *Red lettering on white tape, 1"*
- *Black lettering on yellow tape 2.25"*

2.6.3 LABEL AND TAG ATTACHMENT[4]

In general, labels and tags will be permanently attached to the device specified in such location as to be easily read during normal operation of the device. Panel labels will be smoothly attached to the panel with no overlaps, protrusions, or sharp edges and corners. Laminated plastic or phenolic labels will be attached with permanent adhesive. Printed plastic self-adhering labels must be applied in a craftsperson- like manner and will never be applied over existing phenolic labels. Stainless steel tags for field instruments will be attached to the conduit, right at the instrument, using stainless steel wire sufficient to keep the tag from being unintentionally removed.

Normally, labels will be located on the panel as follows:
Panel 1 through 4 (Parent Equipment tag) is located on the upper right corner of the panel cover with;
Panel 5 or 6 (Component Equipment tag) lined below.
Panel 7 (Related Equipment tag) when required, will be located on the lower right hand side of the panel cover near the bottom.
Panel 8 (Foreign Voltage tag) when required, will be located on the lower right hand side of the panel cover near the bottom.
Panel 9 (Remote MCC tag) is located as closely as possible to the Motor-component of the parent unit.
Panel 10 (Instrumentation tag) Centered **below**; recorders, indicators, controllers, etc.
(Behind-Panel Instruments **must** be labeled.)

See examples at the end of this section.

2.6.4 REAR ACCESS OF CONTROL PANEL DOORS[5]

Where there is access to rear connections of any front panel mounted component, an additional label shall be affixed adjacent to the component at the rear of the panel to carry the tag number or reference symbol of the component. This label must be of a permanent nature. Use Kroy or equal.

2.6.5 TYPICAL PANEL INSTALLATION

A typical installation will have labels/tags attached to the conduits entering the top of the Motor Control Center (MCC). Labels attached by the manufacturer will be left uncovered. Labels for component number, equipment number, and safety will be centered on the panel. MCC/Section/Bucket labels shall be installed on the lower left-hand corner

[4] Section Rev. 2003 Also Section 17100 4.1.2
[5] Also Section 17100 4.1.3

of each bucket. The sizes of the labels shall be appropriate for the application and shall be installed in a craftsperson-like manner.

2.6.6 PRE-APPROVAL

A nameplate schedule showing sizes, layout, and exact locations for all nameplates shall be submitted to the City's project Engineer for approval before any nameplates are prepared.

2.7 ELECTRICAL VAULTS

Of the three voltage classifications:

1. Medium (above 600V)
2. Low (50 to 600V)
3. Communications (50 volts and less)

used at BES, WG facilities, vaults shall only contain conductors carrying voltages of one classification. The only exception to this rule is 115 volt AC to power sump pumps in other than low voltage applications.

Access openings for vaults shall be a minimum of three by three feet (3'x3') with covers sized accordingly.

2.8 EQUIPMENT FINISH

Provide materials and equipment with manufacturers standard finish system. Provide manufacturers standard finish color, except where specific color is indicated. If manufacturer has no standard color, finish equipment with ANSI No. 61, light gray color.

2.9 SERVICE CONDITIONS

Provide materials and equipment rated for installation and operation as specified by the following minimum service conditions:

- Ambient Temperature Range:
  Indoors: -17.77 degrees C, (0 degrees F) to 40 degrees C, (104 degrees F).
  Outdoors: -29 degrees C, (-20 degrees F) to 49 degrees C, (120 degrees F).
- Altitude: Not less than 500 feet above mean sea level.
- Seismic: Uniform Building Code (UBC) Seismic Zone 3.

2.10 HAZARDOUS AREAS

Provide materials and equipment acceptable to the regulatory authority having jurisdiction for the Class, Division, and Group of any hazardous area that equipment or materials are to be installed within.

2.11 HARDWARE SUPPLIED FOR OUTDOORS, MOIST OR CORROSIVE AREAS

Hardware for equipment shall be stainless steel. Hardware shall include, but not be limited to, door handles, latches, bolts, nuts.

2.12 HARDWARE SUPPLIED FOR INDOORS

Hardware for indoor equipment shall be painted steel, galvanized steel, phenolic, stainless steel or Cadmium-plated[6].

3.0 MATERIAL AND EQUIPMENT INSTALLATION REQUIREMENTS

3.1 PERSONNEL AND WORKMANSHIP

All work performed for electrical design, installation, programming and testing of materials and equipment shall be performed by qualified, skilled personnel who are regularly engaged in such activities involving work of similar complexity, and who have all licenses and certificates required to perform such work as required by the Oregon Revised Statutes and Administrative Rules.

3.2 MATERIALS AND EQUIPMENT SHALL BE INSTALLED:

1. In accordance with manufacturer instructions unless approved by the Engineer.
2. So that it is readily accessible to be operated and maintained.
3. All instrumentation and other electronic equipment shall be mounted on non-vibrating surfaces unless approved.
4. Instrumentation shall not be installed in cabinets with voltages in excess of 120 VAC present. Examples of cabinets that Instruments shall <u>not</u> be installed in are VFD's and Disconnects.

3.3 SAFETY

All work performed under these standards, on installations that are under operational control of the BES, shall be done in accordance with the BES energy tag-out/lockout policy and procedures. The project manager shall provide the latest edition.

3.4 HOUSEKEEPING

Keep the premises free at all times from accumulation of waste material, litter, and rubbish. Equipment and materials shall not be left in walk ways, work areas, in front of working equipment or other areas that must be accessed in order to operate and maintain the facilities.

During the project, remove and dispose of any obsolete equipment and materials that will no longer be used as a result of this project including electrical wire back to the source[7].

[6] Rev. 2003
[7] Rev. 2003

Equipment and material to be removed will be at the discretion of the City's project Engineer.

3.5 DE-ENERGIZATION OF EQUIPMENT

De-energization of existing equipment shall be accomplished by the E & I department with at least 48 working hours advance request from the contractor.
As soon as possible, reconnect, reinstall, and restore any systems, equipment or material that was disturbed or taken out of service. Contact the E & I department and coordinate restoring electrical power.

3.6 CARE OF EQUIPMENT AND MATERIAL DURING INSTALLATION

Throughout this Contract, provide protection for materials and equipment against loss, dust, water, moisture or damage. Protect everything from the effects of weather. Temporary space heaters shall be provided (Section 16010, 2.6) and energized to prevent condensation for motor control centers (bottom of vertical section), distribution panels, motors, etc. Follow manufacturers (MFG) recommendations for the care of analytical instrumentation for inactivity or storage during construction and startup phases.

3.7 CUTTING AND PATCHING CITY PROPERTY

Lay out work carefully in advance. Do not cut or notch any structural member or building surface without specific approval from the Engineer. Carefully carry out any cutting, channeling, chasing, or drilling of floors, walls, partitions, ceilings, paving, or other surface(s) required for the installation, support, or anchorage of conduit, or raceways. Following such work, restore surface neatly to original condition. X-ray the above mentioned surfaces as needed to assure that you are not going to destroy needed property, building supports or conduits. Do not notch or penetrate structural members for passage of raceways except with prior written approval of the Engineer.

3.8 EQUIPMENT TESTING

Test shall be performed by individuals assigned by the contractor and/or the equipment supplier under the supervision of the Engineer or his representative. All tests shall be documented in quadruplicate. The documentation shall include:

- Personnel making the test
- Equipment or material tested
- A description of the test performed
- Manufacturer and serial number of the test equipment used, as well as the calibration date of that equipment.
- The test results

The Engineer shall be notified of the time and date of the tests no less than 72 hours prior to the test. All testing that is required by the equipment supplier shall be included in the requirement for testing. Notification of such test shall be made to the Engineer.

Additional tests may be required because of field connections, to ensure equipment meets the requirements of the specifications. The owner shall provide power for all tests. The test procedures and parameters shall be established by the Engineer.

3.8.1 VISUAL AND PHYSICAL CHECK

Check all cables, wires, conduits, enclosures, devices and equipment for correct termination of connections, tightness, and proper installation. **Random checks by E & I staff shall be made and found satisfactory, <u>before substantial completion is granted,</u> and for the development of a punch list.**[8]

3.8.2 INSULATION TESTING (600 volts and below)

Using a 1000 volt megger, test all:
- Wiring
- MCC buss bars
- Transformer windings
- Motor windings
- Associated equipment

Disconnect any equipment that will adversely be affected by the testing. The minimum acceptable reading is 100 megohms. Any portion of the wiring that is below 100 megohms shall be replaced and re-tested until the reading is acceptable. **Testing to be observed by Construction Management Compliance Inspectors**[9]

3.8.3 FUNCTIONAL AND OPERATIONAL TESTING

All power and control equipment shall be tested. This shall be done by operating the equipment in <u>every</u> mode of operation and manually triggering each control or alarm device to see that the equipment functions as it is supposed to. Check out each system and demonstrate that it works as required by the specifications.

3.8.4 PERFORMANCE TESTING OF THREE PHASE ELECTRICAL EQUIPMENT

During performance tests:
- Voltage readings shall be taken on all three phases to check for load and no load conditions and phase balance.
- Amperage readings shall be taken on all three phases to check for load conditions and phase balance.

[8] Rev. 2003
[9] Rev. 2003

3.9 AFTER INSTALLATION

The interior of all electrical equipment, including windings of dry-type transformers, shall be vacuumed and wiped free of dust just before final acceptance.

Following installation, protect materials and equipment from corrosion, physical damage, and the effects of moisture on insulation. When equipment is intended for indoor installation or is installed in areas where it is subject to dampness, moisture, dirt, or other adverse atmosphere, ensure that adequate protection from these atmospheres is provided and is acceptable to the Engineer. Energize all space heaters furnished with equipment.

Touch up scratches, scrapes, or chips in interior and exterior surfaces of devices and equipment with finishes matching as nearly as possible the type, color, consistency and type of surface, of the original finish. If extensive damage is done to equipment paint surfaces, refinish the entire equipment in a manner that provides a finish equal to or better than the factory finish, that meets the requirements of the Specifications, and that is acceptable to the Engineer. Unpainted boxes, cabinets, and raceways that are mounted on walls that are painted or to be painted shall be painted the same color as the walls.

4.0 DOCUMENTATION

4.1 GENERAL[10]

There are 5 major types of electrical drawings that are required (when applicable) for each job. They are:

1. <u>P&ID</u> - shows all process control equipment in three levels.
   This drawing is designed and used in the preliminary engineering phase in planning out the control strategy, and in all other phases along with the process narrative to understand the control strategy. This drawing is revised as necessary through out the project.

   The P&ID is drawn according to ISA standards by drawing a “bubble” for each device, control function, or operator control. Loop numbers shall increase from left to right. P&ID drawings will have three levels, they are:
   - Field - shows all devices used to measure and control the process that are not part of the PLC or the Operator Interface. Examples of these bubbles would be sensors, limit switches, and control valves.

   - PLC/Controller - shows the control functions done by a PLC or a Loop Controller. Examples of the bubbles would be, PID control, alarm signaling, and discreet control. All analog input and outputs shall be shown with their instrument tag numbers.

[10] Also Section 17100 4.1

- Operator Interface - The same as hard instruments with a bubble and tag numbers for each function.

P&ID's shall be provided per ISA S5.1. This drawing is delivered to the E&I manager upon completion for acceptance at each major design review.

Loop drawings - shows all instruments in a loop, wiring connections, and the control parameters. See drawing examples.

- Loop drawings are used to understand and to troubleshoot the loop. This drawing will be developed during the design phase of the project and before the construction drawings.

- Loop drawings shall be provided for all instrument systems per ISA S5.4. Loop drawing shall be provided on 11x17 inch sheets and shall be legible and easy to read. Only **one** loop shall be included on a sheet, however if necessary, one loop may be drawn on more than one sheet.

2. Electrical schematics - shows the electrical circuit in a logical flow of operation. Does **not** show all connection details or equipment location.
   - Electrical drawings are used to troubleshoot the circuits.

   - Electrical drawings will be developed during the design phase of the project before the construction drawings.

   - PLC I/O - shows each I/O card and the wiring and devices connected to each input.
     - Electrical drawings will be developed during the design phase of the project as part of the construction drawings

3. Wiring diagrams - shows all electrical connection information by device in a particular location and between locations.
   - Construction drawings are used to construct the project.

   - Construction drawings shall include interconnection drawings. Interconnecting diagrams which the Contractor shall prepare and submit for approval shall clearly show wire numbers and circuit names, originating terminal numbers, and destination terminal numbers.

   - Construction drawings will be developed in the design phase **after** the loop drawings and electrical drawings are completed.

4. Conduit - shows the "from" and "to" for all conduits as well as conduit tags. Conduit drawings shall also include conductor tables showing all conductors within the individual conduit runs by their tag numbers.

- This drawing will be developed in the design phase after the loop drawings and electrical drawings are completed.
- Physical installation - shows specific information for installing equipment such as dimensions and elevations.
  - This drawing will be developed in the design phase.
- Elevation - shows how panel and distribution equipment will look when installed.
  - This drawing will be developed in the design phase.

5. One lines - a one line diagram of power distribution.
   - This drawing will be developed in the design phase.

4.1 DRAWINGS - GENERAL REQUIREMENTS

See Volume 4, "DRAWING STANDARDS" in the Control System Standards.

4.2 NUMBERING

Please note that numbering for conductors used with instruments are numbered differently than those used for electrical systems.

4.2.1 CONTROL WIRE NUMBERS

Wire numbers for electrical control wiring shall reflect the project number, print number, and line number on which the wire first appears on the print where the wire is shown. The left vertical rail shall be ungrounded conductor (hot wire), and the right vertical rail shall be the grounded conductor (neutral wire). Terminal numbers shall be the same as the wire number. The wire number shall follow the form "AAASNLNA-N" where:

- "AAA"(alpha code) is one to three letters from A to Z that are used to represent the project number under which the wiring was installed. Contractors may obtain these numbers from the City's Engineer. These letters will be incremented one letter at a time and leading letters will not be used. The letters I, O, and Q shall not be used because they are easily confused with the numbers 1 and 0. The leading letter will not be the letter "C" as it is used to identify a conduit.

- "SN"(sheet number) is a number from 1 to 999 that indicates the sheet number of the print on which the wire is documented. Leading zeros are not used.

- "LN"(line number) is a number from 1 to 99 that indicates the line on the print where the wire is located. Leading zeroes will be used.

- "A" (sequential alpha character) is a letter from A to Z that indicates the individual wires on a line of the print. Wires that are electrically identical shall have the same wire number. Wires that connect to the other side of a device (switch, contact, coil,

etc.) shall be assigned the next letter. The letters I, O, and Q, will not be used because they are easily confused with the numbers 1 and 0. The letters G and N shall not be used except where the wires are assigned as ground and neutral respectively.

- "N" is the number given a wire where more than one terminal is given the same wire number.

Neutral wires shall have a distinctive wire number that is not easily confused with any other wire number.
It shall not be necessary to include the project letters on conductors, within a panel or box, that is used exclusively for conductors installed under one project. If project letters are excluded from the conductor tags, the project letters must be identified on the panel label. Any conductor leaving the panel or box must have the full tag number including the project letters.

Relay contact line location shall be shown to the right of the right rail for all lines where a relay coil is shown. Normally closed (NC) contact locations shall be shown with a line over the contact location number.

Devices and sub assemblies that are not custom manufactured for the job may be documented with the manufactures wire numbers and shall not be required to be renumbered. This does not apply to panels and assemblies made specifically for COP, BES projects. VFD's and MCC's are examples of these types of equipment.

4.2.2 INSTRUMENT WIRE NUMBERS[11]

Wire numbers for Instrument Loops shall be as W-XXXX-YY-ZZ, where:

- W is either a Z (Position) or S (Speed). This is only to be used for position or speed of a final control element. In all other cases skip the W and proceed with wire numbering as shown above without the leading "W-".
- XXXX is a four-digit Loop number. Leading zero's are not used.
- YY is a sequential number that begins with one at the first instrument and increments each time the electrical potential changes. When an I/I is in the loop, skip 2 numbers before starting the numbering on the output of the I/I. On the output side of the loop YY starts with 20 and increments each time the electrical potential changes. Leading zero's are not used.
- ZZ is the designation of the terminal block that the wire lands on. This number is different at each end of the wire. The purpose of this number is so that when the wire is disconnected, there will be no doubt as to where it connects.

In Instruments Loops, conductors for analog signals[12] shall be numbered by the convention shown on the preceding page. The conductors for discrete signals[13] shall be numbered by the scheme listed under "CONTROL WIRE NUMBERS".

[11] Section Rev. 2003 Also Section 17100 4.1.4
[12] Rev. 2003
[13] Rev. 2003

Wire labels for AC power to an instrument shall have the instrument tag number and then -H or –N for hot & neutral. See drawing examples.[14]
Wire labels for DC power from the power supply to the terminal blocks shall be labeled as (+) 24VDC (or whatever the voltage is) and (whatever the voltage is)VDC com.
It shall NOT be labeled (–)24VDC! See drawing examples.[15]

4.2.3 INSTRUMENT TAG NUMBERS[16]

- Tag numbers shall be constructed by adding the ISA device mnemonic. Refer to ISA table S5.1, Table 1 on figure 2-1. There will be no changes without Instrument Shop approval.[17] The Loop number, and any suffix numbers as mentioned hereafter. Tag numbers shall comply with ISA Standards as explained hereafter.
- The Contractor shall obtain a block of loop numbers from the Wastewater treatment plants' Instrument Planner. The contractor shall assign tag numbers for each instrument from within that block.
- An Instrument Loop is an instrument or group of connected instruments that measures and / or controls only one variable such as flow or temperature. The initial measurement is made by the primary element. All of the instruments and devices in the loop will have the same base loop number as the primary element. The only exception to this is the application of secondary loops whose primary elements measure the speed or position of a final control element of a primary control loop. A measurement of a VFD speed or control valve position will carry the same loop numbers as the primary loop primary element.[18] A Flow loop senses flow in only one pipe or channel and **does not** sense temperature, pressure, or any other variable. All Instrument Loop numbers will be unique, no two loops will have the same number
- If an Instrument Loop has two or more **parallel** devices that measure or manipulate the same variable, connected to the same indicator, controller or summing device, the transmitters will have the same loop number but they will be suffixed by A, B, C etc. (e.g. FT 100A, FT 100B, FT 100C connected to FIQT 100.)
- If an Instrument Loop has two or more **series** components that are the same, the instruments will be suffixed by -1, -2, -3 etc. e.g., FI 200-1, FI 200-2, FI 200-3. The FI 200-1 will be the first Flow Instrument nearest to the transmitter (as shown on the drawings). The FI 200-2 will be the second Flow Instrument nearest the transmitter etc.

4.2.4 CONDUIT NUMBERS

Conduit and cable number shall follow the form "CAAANNNA" DESTINATION where:

[14] Rev.2003 Also Section 17100 4.1.4
[15] Rev.2003 Also Section 17100 4.1.4
[16] Also Section 17100 4.1.5
[17] Rev. 2003
[18] Rev. 2003

- C indicates conduit or cable.
- AAA is a code that represents the project number that it was installed under. This number is assigned for each project by the City of Portland, Bureau of Environmental Services (COP, BES) Electrical Department.
- NNN is a number that identifies conduits installed on a project. These numbers are to be assigned in a logical order.
- A is a letter from A to Z that identifies conduits that are connected together. On single conduit runs (no tees or junctions) A is always used. The letters I, O, and Q. are not used because they are easily confused with the numbers 1 and 0.
- DESTINATION indicates the location of the other end of the conduit. If the conduit branches, list as many of the major destinations as possible, or the location of the branch. See example at end of this section.

4.3 AS - BUILT DRAWINGS

As-built drawings shall be complete and accurate. Two copies of "as-builts" prints shall be provided on size "D" sheets and three copies on 11" x 17" sheets. The 11" x 17" shall be a reduction of the "D" size print, and shall be legible and clear to read. They shall be provided in a three ring binder with hole reinforcement on each sheet. These and any related construction diagrams shall be delivered to the E & I Manager by the Project Manager when construction is complete, prior to contractor or contractor representative leaving the site. "As builts" shall also be provided on floppy disk, and shall be produced using Auto-cad software of the version currently used by the Wastewater Treatment Plant Engineering Department.
Each set of “as-builts” shall include a drawing (or drawings) showing all conduit runs and the interconnection of all conduits and cables installed in the project, show all buildings, panels, junction boxes, equipment and conduit numbers involved.

Each set of “as-builts” shall also include a print (or prints) with tables for each conduit or cable in the project, showing all the conductors in the conduit. These tables shall be listed by ascending conduit numbers and wires in ascending alphanumeric order. Where raceways and cables are not visible, show locations and elevations.

4.4 RACEWAY TABLE

In addition to the Master Raceway Wiring Table, each electrical or instrument print shall include a table for each conduit or cable that serves conductors on the print. Each table will list <u>every</u> conductor in the conduit or cable that is documented on that print. Where cables are in conduits, the cable shall be documented as a block in the conduit table and an additional cable table shall not be required. Where cables go in wireways, the cable table shall identify the wireway and the location where the cable enters and exits the wireway.

4.5 REQUIREMENTS FOR O&M MANUALS[19]

For electrical equipment, O&M manuals shall meet all the requirements of the "CITY OF PORTLAND DEVELOPMENT GUIDE FOR OPERATION AND MAINTENANCE MANUALS" and the following requirements:

1. All materials shall be installed in standard three ring binders.
2. O&M Manual shall include the following:
   - Equipment Index Table - This table is a page index to all the information in the O&M for each piece of equipment.
   - Equipment Information - provide the following for each instrument or piece of equipment. Instruments and equipment provided as a package shall have this information also provided.
     - Installation instructions
     - Installation Details on all instrumentation field devices
     - Maintenance manuals. Original only, (not photocopies and not on CD).[20]
     - Shipping and handling instructions
     - Outline dimensions
     - Spare parts list
     - Catalog and other identifying information for each type of device including designation of manufacturer, type, and model. Ratings of coils, contacts, switches, push buttons, etc., shall be clearly identified to verify specification compliance. The sheets provided shall only show information for one piece of equipment, and only the equipment provided.
     - Drawings:
       - P&ID
       - Loop
       - Electrical
       - PLC I/O
       - Construction
       - Conduit
       - Physical Installation
       - Elevation
       - Power distribution
       - MCC elevation - each MCC shall be documented individually and shall have a table listing the bucket, its use, and its rating.
     - Data sheets - Fill the data sheets out with as much meaningful information as possible using:
       - ISA S20 forms for all instruments, including process measuring switches (pressure, temperature, etc.).
       - Similar type data sheet for all other equipment including VFD's.

- Provide all configuration and programming documentation of programmable equipment on the manufacturer's parameter or program sheets. This includes all

[19] Also Section 17100 4.1.6
[20] Rev. 2003

programmable instruments (example: mag meters, Milltronics level transmitters, controllers, etc.) and all programmable electrical equipment (example: VFD's, soft starts, etc.).[21]

- A list of all electrical loads for the project. Give the name of the load (example: Sewage Pump #1), the full load rating listing; hp., amps, volts, and the phases.
- Test reports.
- Copies of circuit breaker time current characteristics.
- Operational description.
- Instrument Index. This index shall be a matrix and **shall include** the following minimum information:
    1. Instrument tag number.
    2. Loop drawing number.
    3. Location and number of the data sheet.
    4. The tab of the manuals for the instrument.
    5. The number of any other drawings of which the instrument is part.

Before receiving payments for more than 75% of the work, the Contractor shall deliver to the Engineer four (4) sets of O & M manuals.

4.5.1 MARKING DEVICES

The Contractor shall use waterproof felt tip pens, as required, to maintain record drawings and shall, unless directed otherwise, use the following color coding:

1. Red: Document changes.
2. Blue: Work installed without change.
3. Green: Dimensional and other notations.
4. Dark Yellow: Work deleted.

The Contractor shall maintain one full sized, black-line or blue-line print of Contract Drawings as work set and using marking devices specified above record all required information. Prior to final submittal, transfer recorded information to one additional black-line or blue-line print. Contractor may retain a work-set for his records.

[21] Rev. 2003

Tag Examples and Labelizer Plus Specifications

Parent Equipment tag: (Example of Panel 2)

Panel 1
.50 tape with 2 lines of text
Blue tape with "Reverse On"
Framed: Thin
Line 1 at 0.125 - Caps On
Line 2 at 0.10 – Caps Off

Panel 2
1.125" tape with 2 lines of text
Blue tape with "Reverse On"
Framed: Thin
Line 1 at 0.20" - Caps On
Line 2 at 0.12" Italic – Caps Off

Panel 3
2.25" tape with 2 lines of text:
Blue tape with "Reverse On"
Framed: thin
Line 1 at 0.70" - Caps On
Line2 at 0.40" Italic - Caps Off

Panel 4
4" tape with 2 line of text:
Blue tape with "Reverse On"
Framed: thin
Line 1 at 1.30" - Caps On
Line 2 at 0.70" Italic - Caps Off

Component Equipment tag: (Example of Panel 6)

Panel 5

Panel 6

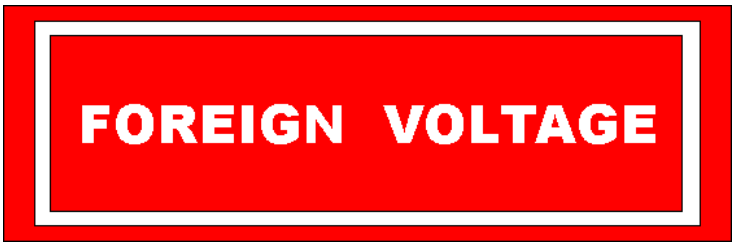
.50” tape with 3 line of text:
Blue tape - White lettering
Framed: Thin
Line 1 at 0.12 - Caps On
Line 2 at 0.08 Italic - Caps On
Line 3 at 0.08 Italic - Caps Off

1.125” tape with 3 lines text:
Blue tape - White lettering
Framed: thin
Line 1 at 0.20 - Caps On
Line 2 at 0.12 Italic - Caps On
Line 3 at 0.12 Italic - Caps Off

Related Equipment tag:

Panel 7
1.125” tape with 2 lines of text
White tape with black lettering
Framed: Thin
Line 1 at 0.30 - Caps On
Line 2 at 0.20 Italic - Caps Off

Foreign Voltage tag:

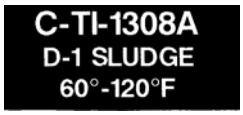


Panel 8
1.125” tape With 1 Line of text
Red tape with white lettering
Framed: Thin
Line 1 at 0.25” - Caps On

Remote MCC tag:

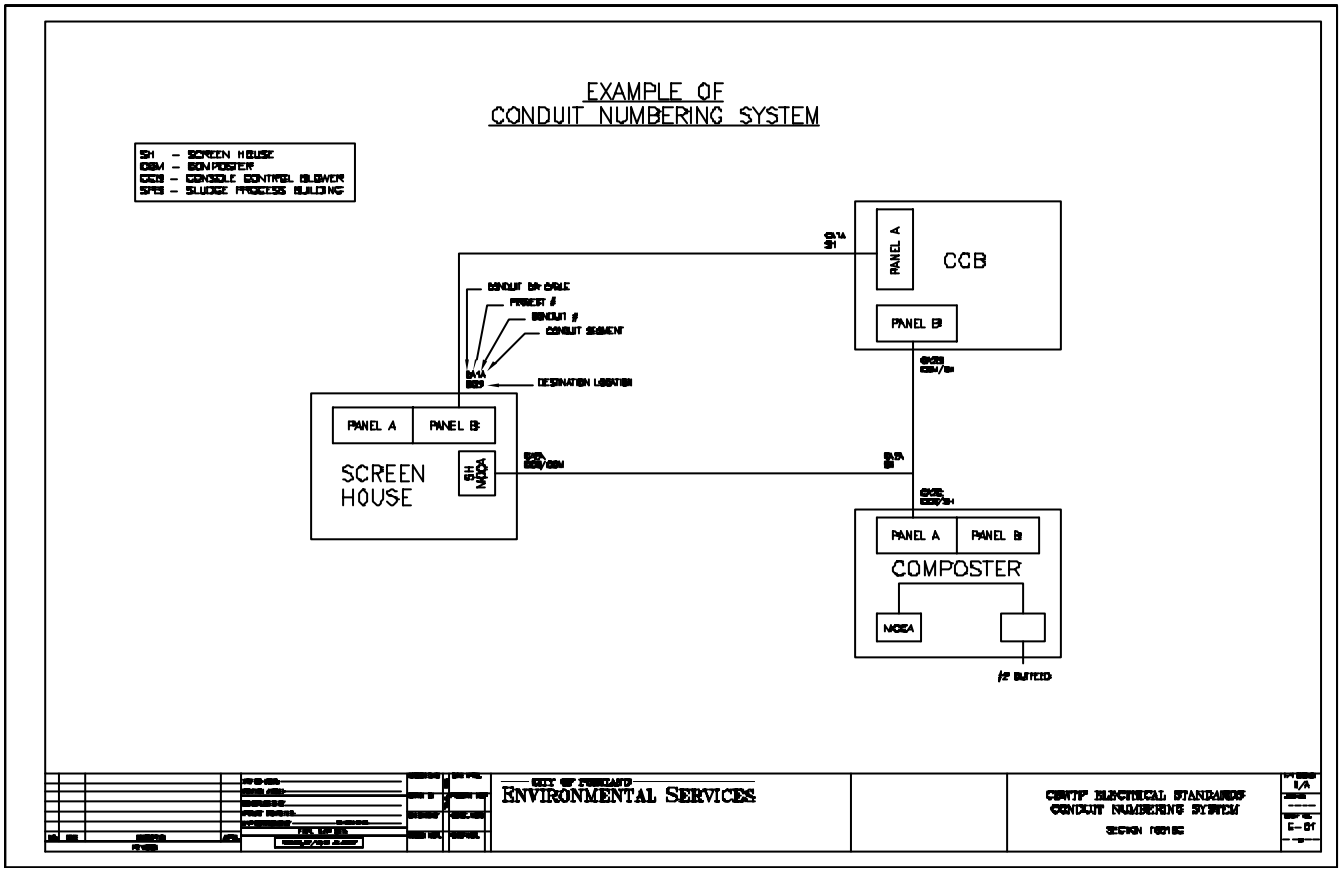
Panel 9
1.125” tape with 1 line of text
Yellow tape with black lettering
Framed: Thin
Line 1 at 0.50” - Caps On

[22]Instrumentation tag:



Panel 10
1.0" tape with 3 (or 4) lines of text
Black tape with white lettering
Line 1 at 0.10” - Caps On
Line 2 at 0.08” - Caps On
Line 3 at 0.08” - Caps Off
Line 4 (as needed) at 0.08” - Caps Off

[22] Also Section 17100 4.1.5


EXAMPLE OF
CONDUIT NUMBERING SYSTEM
SH - SCREEN HOUSE
COM - COMPOSTER
CCB - CONSOLE CONTROL BLOWER
SPB - SLUDGE PROCESS BUILDING
PANEL A
CCB
PANEL B
CONDUIT SEGMENT
DESTINATION LOCATION
PANEL A
PANEL B
SCREEN
HOUSE
SH
MODA
PANEL A
PANEL B
COMPOSTER
MODA
ENVIRONMENTAL SERVICES
CONDUIT NUMBERING SYSTEM