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1.0 SCOPE

This section covers electrical standards for ELECTRICAL SYSTEMS CONTROL and is applicable for electrical design, construction and installation of electrical systems 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. The requirements put forth in the sections listed below shall be considered part of the requirements of this section. If contradictions occur between this section and those listed below, the requirements of this section ***shall have precedence*** when performing work on materials and equipment covered by this section.

SECTION 16010 - BASIC ELECTRICAL REQUIREMENTS
SECTION 16050 - BASIC MATERIALS AND METHODS
SECTION 16480 - MOTOR CONTROL
SECTION 16500 - LIGHTING
SECTION 17100 - INSTRUMENTATION

2.0 MATERIALS PROVIDED

2.1.1 FUSE HOLDERS

Fuse holders shall *not* be of the type that mount through an enclosure panel. All fuse holders *shall* be mounted within an enclosure. Fuse holders shall be rated at 600 volts at 75 deg. C. Fuse holders shall be suitable to the fuse used.

2.1.2 ELECTRONIC FUSE REQUIREMENTS

Electronic fuses shall conform to the following dimensions and fuse holders:

- AGC fuses (6.4 x 31.8 mm) in a PHOENIX UK[1] 6.3 HESI * fuse holder with indicating light capable of being mounted on a 35 mm, symmetrical DIN rail.

- GDR fuses (5 x 20 mm) in a PHOENIX ST SILA or ST-SILED * UK fuse holder with indicating light.

* Use the appropriate voltage

[1] Rev.2003

Substitution of the above products is discouraged and **will require pre-approval** by the I & E department.

2.1.3 FUSE IDENTIFICATION

Adjacent to the fuse holder shall be a label identifying the type of fuse and its size.

2.1.4 FUSING OF INSTRUMENTS

See Section 17010, for details on fusing instruments.

2.1.5 FUSING OF CONTROL CIRCUITS

All “hot” control conductors leaving an enclosure or panel, from which their power is sourced, shall be individually current-limited by a fuse. The intent of this requirement is to keep a shorted conductor in one location from affecting other circuits.

Circuits used for alarming or critical control shall (whenever possible) be designed so that when the fuse blows, the alarm is sounded, or so the Control System does a safe and orderly shut down (Controlled Shutdown).

2.1.6 MOTOR CONTROL TRANSFORMER FUSING

For the primary side of the motor control transformer (on each ungrounded lead), use a 600 volt, time delay, current limiting class "CC" fuse, BUSS CC-TRON FNQ-R or equal. For the secondary side of the transformer, use a 250 volt, time delay fuse, BUSS FNW or equal.

2.1.7 EQUIPMENT REQUIRING INDIVIDUAL FUSES

Each system as listed below shall be fused separately:

- EACH PLC
- INSTRUMENTS OR INSTRUMENT POWER SUPPLIES
- CABINET RELAY LOGIC
- PILOT DEVICES
- ANY FIELD CONNECTED DEVICE

2.1.8 FUSING PLC’s

Control circuits utilizing PLC equipment are, Class 1 Remote Control and Signaling Circuits as applied in the NEC, Art. 725, Part B, and shall utilize for overcurrent protection, BUSS AGC 250 V. fuses 6.4 X 31.X mm or equal.

2.1.9 FUSING PILOT DEVICES

Each pilot device that is field connected and is terminated to a PLC input shall be powered by an individual fuse. Use BUSS GDR 250 V., fuses 5 X 20 mm or equal.

2.1.10 UP AND DOWN STREAM FUSE RATIOS

A ratio of overcurrent protection of upstream to downstream fuses shall be **2:1** or greater. **Example:** Cabinet relay logic and pilot devices using l6 (AWG) MTW is fused at 10 amps (upstream), Field pilot device wired to the PLC input is fused at 3 amps. The ratio is **10 : 3 = 3.33 : 1**

2.2 REQUIREMENTS FOR PLC's

2.2.1 REDUNDANT PLC REQUIREMENTS

Where redundancy is provided, with the use of two or more PLC's, separation of all components shall take place so that it is evident which PLC is associated with which components.

Where there are redundant PLC systems, the branch circuits feeding those systems shall be powered from the same phase. There shall be no sharing of hot or neutral conductors feeding the systems that are redundant. It is acceptable to have a common ground wire for redundant systems.

2.2.2 WIRING TO PLC I/O CARDS

All wiring from terminals located on I/O cards in the PLC, shall be landed on contact blocks before continuation of the circuits take place. All harness wiring from the enclosure door and field wiring shall be landed on terminal blocks provided for that purpose.

2.3 LAYOUT OF COMPONENT IN A CONTROL PANEL

Layout of all components shall be in such a manner that there is a division of all dissimilar components and a collection of all similar components. No component shall interfere with another component in such a manner that physical access or line of sight is denied.

2.4 MINIMUM WIRING REQUIREMENTS IN A CONTROL PANEL

Harness wiring that is 120 VAC shall be 16 (AWG) MTW minimum. Harness wiring that is 24 VDC shall be 16 (AWG) MTW minimum, where individual conductors are

used, and shielded tray cable (type TC) where shielded wire is used, such as Belden cable 9341.[2]

2.5 CONSIDERATIONS FOR CABINETS USED FOR REMOTE CONTROL

Remote control cabinets circuits used for remote control of any electrical apparatus shall be considered to be Class 1 Remote Control and Signal Circuits as defined in NEC, Article 725, Part B.

2.6 RELAYS

2.6.1 GENERAL PURPOSE RELAYS - 15 AMP

Contacts shall be rated 230 VAC 15 amp resistive, and have either a double-pole, double-throw / triple-pole, double-throw (DPDT / 3PDT) arrangement. A pilot light and manual operator shall be included. The coil voltage shall be either 120 VAC or 24 VDC. Use Class 8501 type KX Square D or equal.

2.6.1.2 GENERAL PURPOSE RELAYS - 10 AMP

Contacts shall be rated 230 VAC 10 amp resistive and have either a DPDT/3PDT/4PDT arrangement. A pilot light and manual operator shall be included. The coil voltage shall be either 120VAC or 24 VDC. Use Class 8501 type R Square D or equal

2.6.1.3 GENERAL PURPOSE RELAYS - 5 AMP

Contacts shall be rated 230 VAC, 5 amp inductive and have a four-pole-double-throw (4PDT) arrangement. A pilot light and manual operator shall be included. The coil voltage shall be either 120 VAC or 24 VDC. Use Class 8501 type R Square D or equal.

Note: coil voltages listed are to be used as follows. 120 VAC are to be used for control of non-instrument related equipment. 24 VDC are to be used for INSTRUMENT-related equipment.

2.6.2 SPECIAL PURPOSE RELAYS

These relays are used for latching, timing on, timing off, counting, etc. Contacts are to be rated 230VAC, 10 amps resistive and have a DPDT arrangement. The coil voltage shall be 120 VAC. The pin arrangement shall be either 8 or 11 pins and shall be programmable (digital). Use Class 9050 type JCK Square D or equal.

2.6.3 RELAY BASES

All contact blocks and bases for general-purpose relays, and special purpose relays, shall be capable of being mounted on 35-mm symmetrical DIN rail. DIN rail, where used,

[2] Rev.2003

shall extend the full length of the space provided within 1/8 inch of each end of that space. It is acceptable to splice DIN rail provided the butted ends are square and properly aligned. DIN rail must be 35-mm symmetrical, where used.[3]

2.6.4 MACHINE TOOL RELAYS

2.6.4.1 600 VOLT

Contacts shall be rated at 600V 10 amp, and shall be easily converted from normally open (NO) to normally closed (NC). The relay shall have provisions for four (4) poles and be adaptable for additional poles, as needed. There shall be provisions for additional equipment (timers, time delays, etc.). The coil shall be rated 120 VAC.

2.6.4.2 300 VOLT

Provide magnetic control relays, NEMA Class A300 (300 volts, 10 amps continuous, 7,200 volt amps inrush current and 720 volt amps contact opening), machine tool type. Relay contacts shall have the current and voltage rating required for the application, but not less than required in NEMA Standard ICS, Part 2-125

2.6.4.3 GENERAL REQUIREMENTS

Provide magnetic control relays meeting the requirements of NEMA Standard ICS, Part 2-212. Contact arrangement shall be readily convertible in the field, NO to NC and vice versa. Provide Cutler-Hammer Type M-300, Westinghouse Type ARB, Allen Bradley Bulletin-700 or equal.

2.6.5 CONTROL RELAYS

Control relays shall be GE CRI20, Allen-Bradley 700N, Cutler-Hammer D23 or D26, Potter Brumfield KHU, or approved equal. Specific relay types and /or contacts shall be suitable for the application. Relays shall be supplied with the number of contacts specified, but no less than four contacts per relay. Contacts which are not integral to the relay shall be of the convertible type. Relays supplied shall be of one interchangeable type to the greatest extent as is practical.

2.6.5.1 CONTROL RELAY IDENTIFICATION

Each relay shall be identified with a durable and legible label (mounted on the panel near the relay base) with the relay number or function as shown on the Drawings.

2.6.5.2 CONTROL RELAYS IN SWITCHING LOADS
Control relays used in switching loads (solenoids, actuators, contactors, motor starter coils, etc.) shall be heavy-duty machine tool types. Relays that have contacts used for

[3] Also Section 17100 2.5.1

remote interlocking, or for which the switching load is not shown, shall also be heavy-duty machine tool types. Contacts shall be four pole (as a minimum) and be field interchangeable to either NO or NC. Relays shall accept a four-pole adder.

2.6.5.2 AC CONTROL RELAYS

AC relays shall have NEMA A600 contact ratings and electrical clearances for up to 600 volts. DC relays shall have NEMA P300 contact ratings and electrical clearances of up to 250 volts.

2.6.5.3 LOGIC SWITCHING CONTROL RELAYS

Control relays (used for switching logic, other relays, etc.) shall have a minimum of three (3), single-pole-double-throw (SPDT) contacts that are rated 10 amps resistive at 120 VAC or 28 VDC. Relays shall be plug-in type with heavy duty, barrier protected screw terminal sockets (pressure block) and clear polycarbonate dust covers with clip fasteners. AC models shall have neon lamp indicators wired in parallel with relay coils. Logic switching control relays shall be Potter-Blumfield series KUP, Struthers-Dunn frame 219 or approved equal.

2.6.5.4 SIGNAL LEVEL SWITCHING CONTROL RELAYS

Control relays used for switching DC milliamp (mA) signals shall have a minimum of two single-pole, double-throw (SPDT), hermetically sealed, gold-flashed, bifurcated contacts that are rated at 3 amps resistive at 120 VAC or 28 VDC. Relays shall be plug-in types with heavy duty, barrier protected screw terminal sockets. Relay covers shall be either metal or clear polycarbonate. Control relays used for switching DC mA signals shall be Potter-Blumfield series KHS, Magnecraft class 78 or approved equal.

2.6.5.5 POWER FAIL RELAY

When indicated on the Drawings; furnish, install, connect, and test a fused, 3-phase power fail relay (PFR). The relay shall simultaneously monitor all three phases for pre-selected under and over voltage limits. The relay shall have a fixed delay on dropout to accommodate start-up transients. The relay shall include double-pole, double-throw (DPDT) auxiliary contacts rated IOA at 120 VAC, and shall be designed for operation on a 480Y / 277 VAC, wye connected system. Use Diversified Electronics PBC-977 / 4S0-ALE, or approved equal. These relays shall be used for annunciation of HYDRA alarm system.

2.6.5.6 TIME DELAY RELAYS

Where time delay relays are specified or required, unless otherwise noted, provide magnetic control relays with a solid-state (pneumatic type *not* acceptable) timer

attachment adjustable from 0.2 to 60 seconds (minimum) and field convertible from ON delay to OFF delay and vice-versa.

2.6.6 TIMERS

2.6.6.1 MOTOR DRIVEN TIMERS
All motor-driven timers shall be operated by a synchronous motor and shall have a "progress" time pointer attached. Motor driven, repeat cycle timers shall have a "set" time pointer attached. Motor driven reset timers shall be provided with two delayed single-pole-single-throw (SPST) contacts, which are rated at 10 amps resistive at 120 VAC. Motor-driven timers shall be ATC, Eagle Signal, or approved equal.

2.6.6.2 SOLID STATE TIMERS

On /Off, Repeat-Cycle Timers shall alternate time off and time on periods as long as power is applied to the timer. On or off timing periods shall be indicated by pilot lights and be independently adjustable. Timers shall have a minimum of two single-pole, single-throw (SPST) contacts rated at 5 amps, at 120 VAC and automatically reset upon loss of power.

2.6.6.3 MECHANICAL LATCHING RELAYS

Where latching (mechanically held) relays or motor thermal detector relays are specified, provide magnetic control relays with mechanical latch attachment with unlatching coil and coil clearing contacts. Utilize an attachment allowing easy manual latching and unlatching.

2.7 INDICATING LIGHTS

2.7.1 SPECIFICATIONS

All indicating lights shall use the “BA9S” socket (single lamps), configured for push-to-test. Miniature pilot lights for 24 VDC shall be Allen Bradley 800T, Square D Class 9001 type J, or approved equal.

2.7.2 LENS COLORS FOR INIDCATING LIGHTS

Pilot light lens colors shall be as follows:

Electrical Condition	**Valve Position**	**Lens Color**
On /Energized	Open	Red
Off /De-energized	Closed	Green
Fault /Alarm		Blue
Abnormal	Abnormal	Amber
Power Available		White

Push-buttons, selector switches and pilot lights shall be as follows, unless otherwise indicated:

LOCATION	DRY LOCATIONS	OTHER LOCATIONS
Integral with separately mounted controllers	Manufacturer's standard.	Oil-tight heavy duty type
Integral with motor control centers:	Oil-tight, heavy duty type	Oil-tight, heavy duty type
Separately mounted	Oil-tight, heavy duty type	Oil-tight, heavy duty type
Outdoor and Wet Locations (Pump Floor)	NEMA 4X stainless steel	NEMA 4X stainless steel
Concealed Conduit Locations	Flush mounted NEMA 12	Flush mounted NEMA 12
All other locations	Surface mounted NEMA 12	Surface mounted NEMA 12

2.8 PILOT CONTROLS

2.8.1 PILOT CONTROLS (flow switches, float switches, limit switches etc.)

Pilot controls (other than those used in Instrument systems) shall operate at 110 to 120 VAC and have a blown fuse indicating fuse holder. Pilot controls on process control systems shall operate on 24VDC, when possible.

2.8.2 PILOT CONTROL IDENTIFICATION

Labels shall correspond to equipment number, pilot device name and equipment served.

2.8.3 PILOT CONTROL SPECIFICATIONS

Where possible, provide pilot devices with scales indicating the current setting, as they can be set, roughly to the desired setting before final calibration. Pilot controls shall be Mercoid, Ashcroft or approved equal.

Pressure switches (Mercoid or approved equivalent) float switches, limit switches, and similar devices shall be heavy duty, conform to the general requirements for control units as applicable and shall be applied within their electrical, mechanical and environmental ratings.

2.9 VARIABLE FREQUENCY DRIVES

Each VFD shall be provided with data sheets, similar to ISA S20, that provide a minimum of: Model #, Serial #, MFG., Voltage, Amperage, Frequency, Ramp rates and any other field adjusted variables. Each VFD shall meet the requirements of IEEE, section 519, for harmonics (<5%) at the point of common coupling.

2.10 DEVICES MOUNTED IN PANELS

2.10.1 ELAPSED TIME METERS

Provide: synchronous-motor-driven, elapsed time meters, 0 to 99,999.9 hours range, non-reset type, suitable for semi-flush panel mounting. Meters shall be housed in a 2-1/2 inch square case and configured for flush panel mounting. Meters shall have a 7 digit, non-reset register with the last digit on the right indicating tenths of an hour. Meter face shall be white or aluminized with black trim. Provide General Electric Type 240, 2-1/2 inch Big Look Unit, Eagle Signal Bulletin 705 unit, or equal.

2.10.2 IDENTIFICATION - PUSH BUTTON AND SELECTOR SWITCHES

Each push button and selector switch shall be provided with an engraved metal Nameplate, indicating its function, such as start, stop, etc. In addition, each control, or group of controls, shall be provided with an engraved nameplate indicating the function controlled, such as "Pump No. 1". Each separate pilot light shall have an engraved nameplate indicating its function, such as "High Water Alarm".

Push Button Switches shall use the following Color Code:

Inscription	**Color**
ON OFF	Green Red
OPEN CLOSE	Black Black
START STOP	Green Red
RESET	Red
EMERGENCY STOP	Red
FORWARD REVERSE	Black Black
RESET	Red

Label Definitions used on selector switches:

With each piece of motorized equipment there will be a LOCAL CONTROL PANEL (LCP) within sight of the equipment. There is only one (1) LCP. Even if a motor starter

is capable of starting or stopping the equipment, it is **not** the LCP unless there is not **another control station within sight of the equipment**.

Maintaining selector switches **will not be used** to control a motor. STOP/START buttons **must** be used to start the equipment.

- NAMES THAT ARE USED **ONLY** AT THE LCP:

  1. HAND means that the equipment is being controlled at the LCP. A start/stop station must be supplied on the panel. Equipment speed (for equipment with variable speed drives) will be controlled from a rheostat after the start button has been pushed.

     - Names for pushbuttons associated with HAND portion of the LCP:
       1. STOP will cause the equipment to stop.
       2. START will cause the equipment to start. Some safeties may not need to be satisfied to enable the equipment from the LCP.
     - Names for labels on switches used in conjunction with the HAND switch:
       1. FVC means that the motor that drives the equipment is being operated manually across the line.(at full line voltage/full speed)
       2. VFD means that the motor that drives the equipment is being controlled manually at, or less than, full line voltage and full speed.

     NOTE: If only one selector switch is used on the LCP, HAND may be omitted and the labels FVC and or VFD may be used.

  2. OFF means that the equipment is off. The equipment cannot be started from any other location. This only appears on the label at the LCP.

  3. REMOTE refers to any location other than the LCP. When the switch is in REMOTE, the equipment may be stopped or running in any operating mode. The remote controller location and the Computerized Maintenance (COMA) equipment number is listed on the label.

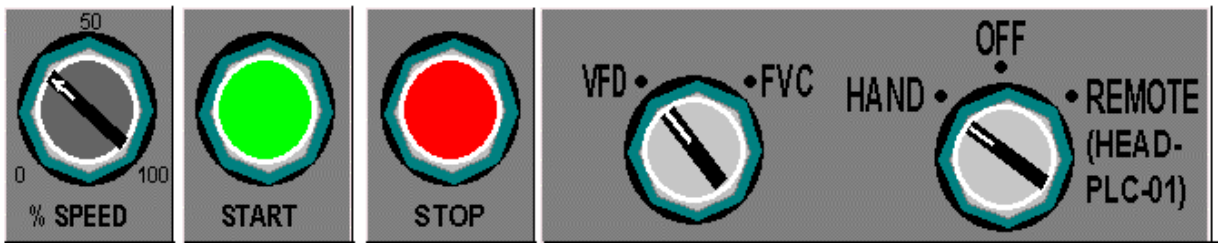
- NAMES THAT ARE ONLY USED AT THE HMI (HUMAN MACHINE INTERFACE - iFIX)

  1. OPERATOR CONTROL means that an operator is instructing the PLC how to operate the equipment. The LCP and some safeties can preempt this instruction from being completed.
     - Names for pushbuttons associated with OPERATOR CONTROL:
       STOP will cause the equipment to stop.
       START will cause the equipment to start. All safeties must be satisfied before equipment will start.

2. PLC CONTROL means that the equipment is being controlled by a PLC or a Controller, not by an operator.

NOTE: "AUTO", "LOCAL" and "ON" will not be used on switch labels.

A LCP WILL INCLUDE MOST OR ALL OF THE FOLLOWING SWITCHES:



2.10.3 NEMA RATING OF DEVICES MOUNTED IN CABINETS

The NEMA rating of all push buttons, indicating lights, selector switches, etc., shall be the same as the enclosure in which they are installed.

2.10.4 GROUPING OF CONTROL DEVICES

All control buttons, switches, lights pots, etc. shall be grouped in a logical sequence so as to aid in the operation of the equipment being served.

2.10.5 STOP BUTTONS

Stop buttons and switches shall be wired so that the stop function is performed with no other operations. The stop button shall not be used as an emergency stop. The use of collars, maintained buttons /switches, or other such devices that open the control circuit shall not be used as a disconnecting means when designing equipment for lockout, tag-out procedures.

2.10.6 TERMINAL BLOCKS[4]

All terminal blocks are required to be mounted to 35mm Din Rail. All terminal (contact) blocks are to be compatible with Phoenix Systems indicated below.

Fixed bridge / insertion bridge shall utilize a center-to-center distance of 5.2mm between terminal blocks. Screws used for fixed bridge applications shall be capable of being replaced with a test plug socket that receives a 2.3mm test plug.
Knife-style disconnect blocks shall be capable of receiving a 2.3mm test plug in the socket screws which are used to secure the wire(s) to the terminal block.
Base terminal blocks shall be capable of receiving the following devices:

[4] New Section 2003

- Phoenix Disconnect Plug ST-K4
- Phoenix Component Plug ST-BE
- Phoenix Fuse Plug ST-SI-UK4
- Phoenix Fuse Plug ST-SILA 250 UK4

Use Phoenix Contact Terminal Blocks and Components

- UK4 Terminal Block
- D-UK 4/10 End Cover
- USLKG 5 Ground Terminal Block
- UK4-TG Base Terminal Block
- ST-BE Component Plug
- ST-K4 Disconnect Plug
- ST-SILED 12-UK4 Fuse Plug
- ST-SILED 24-UK4 Fuse Plug
- ST-SILA 250-UK4 Fuse Plug
- UK5-MTK-P/P Knife Disconnect Terminal Block
- E/NS 35N Universal End Bracket
- KLM-A Terminal Strip Marker
- UK5-HESI Fuse Block