ELECTRICAL DESIGN STANDARD

Lift and Pump Stations

Abstract

Electrical and instrumentation design criteria for the City of Regina wastewater and stormwater lift stations. This document is intended to describe the control functionality and philosophy for the various elements in this system.

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Introduction

This document outlines electrical and instrumentation design criteria for the City of Regina wastewater and stormwater lift stations. It is intended to describe control functionality and philosophy for the various elements in this system.

Control System – Functional Configurations

The control system is composed of a Programmable Logic Controller (PLC) at each lift station site and a centrally located SCADA system. PLCs are of common manufacture to minimize the required number of spare parts and to minimize varieties of software required for programming. In special situations (monitoring stations), a level transducer or other remote terminal unit capable of communications with SCADA will be used rather than a PLC. Each site has its own PLC to facilitate control of its pumping system, and SCADA is used solely to monitor system operation and gather relevant data from each site. All sites are connected to SCADA by radio or dial-up telephone modem.

Lift Station Monitoring Standards

Lift stations have been categorized into two basic types:

- Small lift stations are considered those with two or fewer pumps rated at less than 25Hp each, do not have a backup generation system or backup engine pumps.
- Large lift stations are considered those with two or more pumps rated at 25Hp or larger or a site with a backup generation system.

Also included are monitor sites, which are further than 300 metres from any lift station but are considered important to monitor system-level or flow.

The following table summarizes the minimum recommended points to be implemented at lift stations or monitoring sites for subsequent display or storage by the SCADA system.

Point Description	Tag Prefix	Monitor Site	Small Lift Station	Large Lift Station
Electric Pump Run Status	YI		Yes	Yes
Electric Pump Available Status	YY		Yes	
Electric Pump Auto Status	HSA			Yes
Electric Pump Fault Status	UA		Yes	Yes
Electric Pump Moisture Status	MSH			Yes
Electric Pump Temperature Status	TSH			Yes
Electric Pump Run Control	XC		Yes	Yes
Electric Pump Elapsed Run Time	KQI		Yes	Yes
Electric Pump Start Counter	XQI		Yes	Yes
Engine Pump Run Status	YI			Yes
Engine Pump Auto Status	HSA			Yes
Engine Pump Fault Status	UA			Yes
Engine Pump Run Control	XC			Yes
Engine Pump Elapsed Run Time	KQI			Yes
Engine Pump Start Counter	XQI			Yes
Wet Well High-Level Float	LSH/LSHH		Yes	Yes
Wet Well Low-Level Float	LSL/LSLL		Yes	Yes
Wet Well Level Transmitter	LT/LIT		Yes	Yes

Ancillary Level Transmitter	LT/LIT	Yes		Yes
Dry Well Flood Float	LSHH		Yes	Yes
UPS System Alarm	ESL	Yes	Yes	Yes
Utility Power On	ESL	Yes	Yes	Yes
Transfer Switch Position	ZS			Yes
Generator Fault Status	UA			Yes
Building/Panel Security	ZSO	Yes	Yes	Yes
Building Fire	TKSH		Yes	Yes
Building/Panel Low Temperature	TSL	Yes	Yes	Yes
Building/Panel High Temperature	TSH	Yes	Yes	Yes
High H2S Status	ASH		Yes	Yes
Ventilation Failure	FSL		Yes	Yes
Flow Transmitter	FT/FIT			Yes
Flow Totalization	FQI		Yes	Yes

Notes:

- Pump available status, which is used on small lift stations, includes the failsafe series wiring of pump statuses such as auto mode, overload fault, pump moisture and temperature.
- Pump fault status shall be wired failsafe such that an overload, loss of power, and other interlocks trigger the fault signal.
- An ancillary level transmitter is the level transmitter associated with a monitor site (maintenance hole, creek, detention facility or channel level). Most sites are within 300 metres of another lift station and are thus monitored by that lift station. Those sites that are not near other lift stations, but are deemed important to monitor, will be provided with their level transmitter and remote terminal unit.
- H2S monitoring to be provided for all wastewater lift stations.
- Electric pump motor moisture and temperature monitoring are recommended to be installed on submersible pumps rated over 5Hp.

Lift Station Control Standards

The City of Regina presently has three different lift station arrangements, each with different concerns when it comes to equipment selection and configuration, as follows:

Manhole Type Lift Stations with Control Panels Above Ground Level

- PLC mounted inside a weather-rated control panel
- Communication equipment within the control panel
- Due to the risk of vandalism, no indicators or control switches on the panel exterior
- Panel heater complete with thermostat
- Security limit switch on the panel door
- Use battery-backed 24 VDC system for critical panel equipment.
- Use a separate panel for service entrance and pump starter equipment.

Manhole Type Lift Stations with Control Panels in a Building

- PLC mounted inside a control panel
- Pump HOA switch and indicators mounted on separate pump starter panel(s)
- Communication equipment within the control panel
- Security limit switch on building door(s)
- Provide battery-backed 24 VDC system or 120 VAC UPS system to support level transmitter, DC power supply, communications equipment and PLC controller.

- HMI mounted on control panel door for easy viewing

Large Lift Stations

- PLC mounted inside of control panel
- Communication equipment within the control panel
- Pump HOA switch and indicators mounted on separate pump starter panel(s)
- Security limit switch on building door(s)
- Provide battery-backed 24 VDC system or 120 VAC UPS system to support level transmitter, DC power supply, communications equipment and PLC controller.
- HMI mounted on control panel door for easy viewing

The City of Regina will not accept any new lift stations with control panels below ground level due to health and safety issues. Any new construction with maintenance holes for pumps will be designed with either the control panels above ground or within an adjacent small building. Any new wastewater lift station buildings above a maintenance hole shall be constructed with two isolated rooms with separate exterior entrances, one for the maintenance hole access and one for the service entrance, motor starters and control equipment.

Service Voltage Standards

Optimally the service entrance to lift stations shall be 600/347 VAC 3-phase 4-wire. If a 600 VAC service is not practical or the requirements are less than 50 kVA, the service entrance may be provided at 208/120 VAC.

Emergency Back-up Generation Standards

Whenever the lift station design process indicates the emergency backup generation requirement, the electrical power generation system is to be designed for standby service in an unattended mode, complete with an automatic transfer switch. The system shall consist of the following major items:

1. Engine
    - The engine shall be natural gas, four-cycle, integral radiator and cooling fan. The engine's horsepower rating at its minimum tolerance level shall be sufficient to drive the alternator and all connected accessories.
    - An electronic governor system shall provide automatic isochronous frequency regulation.
    - Electric starter(s) capable of six (6) complete cranking cycles without overheating.
    - The engine shall have positive displacement, mechanical, full pressure, lubrication oil pump.
    - The engine shall have full flow lubrication oil filters with replaceable spin-on canister elements and dipstick oil level indicator.
    - The engine shall have a replaceable dry element air cleaner with a restriction indicator.
    - The engine shall have a fuel filter with a replaceable spin-on canister element.
    - The engine shall have an oil drain extension and under-engine removable drip pan.
    - Engine mounted battery charging alternator and solid-state Voltage regulator.

2. Alternator
    - The AC generator shall be; synchronous, four-pole, 2/3 pitch, revolving field, drip-proof construction, single pre-lubricated sealed bearing, air-cooled by a direct drive centrifugal blower fan, Class H insulation system and directly connected to the engine with flexible drive disc.
    - The generator shall be capable of rated output (kVA) at rated frequency and power factor, at any Voltage, not more than five (5) percent above or below rated Voltage.
    - A permanent magnet generator (PMG) shall be included to provide a reliable source of excitation power for optimum motor starting and short circuit performance.
    - High ambient cooling system (50° C).
    - Frequency shall be 60 Hz steady-state at rated kW (manually adjustable ±2.5%).
    - Steady-state Voltage, nominal L-L at rated kW.
    - Operating configuration 3-phase, 4-wire, grounded neutral with broad range re-connectable 12 leads.
    - The Voltage regulation system shall be equipped with 3-phase RMS sensing and shall control the buildup of AC generator Voltage to provide a linear ruse and limit overshoot. Regulation, 0 to 100% load of ±2%.
    - Unit mounted load breaker, sized to protect the alternator.
    - Total harmonic distortion less than 4% (per NEMA M61-22-42).
    - Telephone influence factor less than 50 (per NEMA M61-22-43).

3. Control Cubicle
    - The generator set shall be provided with a microprocessor-based control system designed to provide automatic starting, monitoring, and control functions for the generator set. The control system shall also be designed to allow local monitoring and control of the generator set and indicated remote monitoring and control points.
    - The control shall be mounted on the generator set with all switches, lamps and meters being oil-tight and dust-tight, and the enclosure door shall have a gasket

.

    - Three-position control switch labelled RUN/OFF/AUTO.
    - Red pushbutton EMERGENCY STOP switch.
    - Pushbutton RESET switch shall be used to clear a fault and restart the generator set after it has shut down for any fault condition.
    - The generator set shall be provided with a metering set including the following features and functions:
        i. 0.5% accuracy.
        ii. Generator RMS Voltage (L-L and L-N) shall simultaneously display all three-phase Voltages (L-L or L-N).
        iii. Generator RMS current.
        iv. Frequency.
        v. Output kW.
        vi. Output kW-hours.
        vii. Generator power factor.

viii. Engine oil pressure (kPa).
ix. Engine coolant temperature (°C).
x. Engine oil temperature (°C).
xi. Engine speed (rpm).
xii. The number of hours of operation (hours).
xiii. The number of start attempts.
xiv. Battery Voltage (DC Volts).

- The generator set shall be provided with alarm and status indicating lamps to indicate non-automatic generator status and standing alarm and shutdown conditions. The lamps shall be high intensity LED type. The generator set control shall indicate the existence of the following alarm and shutdown conditions on a digital display panel:
  i. Low oil pressure (alarm)
  ii. Low oil pressure (shutdown)
  iii. Oil pressure sender failure (alarm)
  iv. Low coolant temperature (alarm)
  v. High coolant temperature (alarm)
  vi. High coolant temperature (shutdown)
  vii. Engine temperature sender failure (alarm)
  viii. Low coolant level (alarm or shutdown – selectable)
  ix. Fail to Crank (shutdown)
  x. Overcrank (shutdown)
  xi. Overspeed (shutdown)
  xii. Low DC Voltage (alarm)
  xiii. High DC Voltage (alarm)
  xiv. Weak battery (alarm)
  xv. Low fuel – day tank (alarm)
  xvi. High AC Voltage (shutdown)
  xvii. Low AC Voltage (shutdown)
  xviii. Under frequency (shutdown)
  xix. Overcurrent (warning)
  xx. Overcurrent (shutdown)
  xxi. Short circuit (shutdown)
  xxii. Ground fault (alarm – when required by code or specified)
  xxiii. Overload (alarm)
  xxiv. Emergency Stop (shutdown)
  xxv. Two customer-specified alarm or shutdown conditions.
- The generator set shall provide common alarm and running contacts for status to the lift station PLC control system.

4. Automatic Transfer Switch
   - Size of transfer switch equipment, number of poles, Voltage and Ampere ratings as required.
   - Main contacts shall be rated for 600 Volts AC minimum.

- Transfer switches shall be rated to carry 100% of rated current continuously in the enclosure, in ambient temperatures of -40° to +50° C, relative humidity up to 95% (non-condensing), and altitudes up to 10,000 feet (3000m).
- Transfer switch equipment shall have a withstand and closing rating (WCR) in RMS symmetrical Amperes greater than the available fault currents. The transfer switch and its upstream protection shall be coordinated. The transfer switch shall be third-party listed and labelled for use with the specific protective device(s) installed in the application.
- Transfer switches shall be double-throw, electrically and mechanically interlocked, and mechanically held in both positions.
- Transfer switches shall be equipped with permanently attached manual operating handles and quick-break, quick-make over-centre contact mechanisms suitable for safe manual operation under load.
- Main switch contacts shall be high-pressure silver alloy. Contact assemblies shall have arc chutes for positive arc extinguishing. Arc chutes shall have insulating covers to prevent interphase flashover.
- Provide one set Form C auxiliary contacts on both sides, operated by transfer switch position, rated 10 A 250 VAC.
- Provide a neutral bus and lugs, sized to carry 100% of the current designated on the switch rating.
- Provide automatic Controls with features as follows:
    i. Transfer switches shall be provided with a fully automatic control system and provisions for manual operation.
    ii. Control shall be solid-state and designed for a high level of immunity to power line surges and transients. The control shall have optically isolated logic inputs, high isolation transformers for AC inputs, and relays on all outputs.
    iii. Solid-state Undervoltage and overvoltage sensors shall simultaneously monitor all phases of both sources. Pickup and dropout settings shall be adjustable. Voltage sensors shall have field calibration of actual supply Voltage to nominal system Voltage.
    iv. Controls shall be provided with a solid-state over and under frequency sensor to monitor the normal and emergency sources. Pickup bandwidth shall be adjustable from a minimum of ±4% to a maximum of ±20% of the nominal frequency. Dropout shall be ±5% of nominal wider than pickup frequency bandwidth.
    v. Provide Phase Sequence Monitor and Balance module to protect against inadvertent phase rotation hookup and monitor for Voltage phase imbalance between phases.
    vi. The switch shall transfer when the emergency source reaches the set point voltage and frequency. Provide a solid-state time delay on transfer 0 to 120 seconds.
    vii. The switch shall retransfer the load to the normal source after a time delay retransfer, adjustable from 0 to 30 minutes. Retransfer time delay shall be immediately bypassed if the emergency power source fails.

viii. Transfer switches shall be equipped with field adjustable controls to allow the operator to control the transfer switch operating time during switching in both directions. The controls shall control the time the load is isolated from both power sources to allow load residual Voltage to decay before closure to the opposite source. The transfer switch operating speed control feature shall have an adjustable range of 0 to 7.5 seconds. A phase angle monitor is not an acceptable substitute for this feature.

ix. Controls shall signal the engine-generator set to stop after a time delay, adjustable from 0 to 10 minutes, beginning on return to the normal source.

x. Power for transfer operation shall be from the source to which the load is being transferred.

xi. The control shall include latching diagnostic indicators to pinpoint the last successful step in the sequence of control functions and to indicate the present status of the control functions in real-time, as follows:
    1. Source 1 OK
    2. Start Gen Set
    3. Source 2 OK
    4. Transfer Timing
    5. Transfer Complete
    6. Retransfer Timing
    7. Retransfer Complete
    8. Timing for Stop

xii. The control shall include remote transfer inhibit and area protection features.

xiii. A key operated selector switch to provide the following positions and functions:
    1. Test – Simulates normal power loss to control for testing of the generator set. Controls shall provide for a test with or without load transfer.
    2. Normal – Normal operating position.
    3. Retransfer – Momentary position o override retransfer time delay and cause an immediate return to normal source, if available.

xiv. Transfer switch position and source available lamps.

xv. Meters: Provide an AC Voltmeter, an Ammeter, and a Frequency meter. 2.5 inch, analog, 2% accuracy. Provide a phase selector switch to read the L-L Voltage and current of both power sources.

xvi. Signal Module: Provide a signal module to delay the transfer and retransfer of the switch for up to 50 seconds to provide a pre-transfer warning signal contact. Provide signals for the following conditions:
    1. Source 1 Available
    2. Source 2 Available
    3. Test/Exercise
    4. Backup Source Available
    5. Contacts for these functions are to be form C type, rated for 120 VAC or 30 VDC at 4 Amps.

5. Battery Charger

- A UL listed/CSA certified 10 Amp Voltage regulated battery charger shall be provided for each engine generator set. The charger shall be wall-mounted. Input AC Voltage and DC output Voltage shall be as required. Chargers shall be equipped with float, taper and equalize charge settings. Operational monitors shall provide visual output along with individual form C contacts rated at 4 Amps, 120 VAC, 30 VDC for remote indication of:
    i. Loss of AC power – red light
    ii. Low battery Voltage – red light
    iii. High battery Voltage – red light
    iv. Power on – green light (no relay contact)
    v. Analog DC Voltmeter and ammeter, 12 hours equalize charge timer, AC and DC fuses shall also be provided on the charger.

6. Starting Battery with Rack Stand Enclosure
    - Starting battery bank, calcium/lead-antimony type, 24 VDC sized as recommended by the generator set manufacturer, shall be supplied for each generator set with battery cables and connectors. A separate marine-type non-metallic case mounted separately from the engine generator skid shall be provided to house the battery bank.

7. Fuel Supply System
    - Fuel supply shutoff valves
    - Flexible supply fuel lines to the engine
    - Natural gas fuel surge tank

8. Engine Exhaust System
    - Heavy-duty, critical type approved by the engine manufacturer. Expansion joints, stainless steel, braided flex to absorb the vertical and horizontal expansion. The exhaust system shall be installed according to the generator set manufacturer's recommendations and applicable codes and standards.

9. Engine Cooling System
    - Integral mounted radiator, radiator and cooling system rated for full load operation in 122° F (50° C) ambient as measured at the air inlet. The cooling system shall be filled with 50/50 ethylene glycol/water mixture by the equipment supplier.
    - A low-level alarm switch (LSLL) with a Form C dry alarm contact, rated 2 A @ 30 VDC, shall be provided to indicate the existence of a low coolant level.
    - Engine mounted, thermostatically controlled, circulating coolant heater(s) sized as recommended by the engine manufacturer to warm the engine to a minimum of 100° F (40° C) in a 40° F (4.5° C). Coolant heater shall be HOTSTART TPS series or approved equal.

10. Mounting Base
    - The engine-generator set shall be mounted on a heavy-duty steel base to maintain alignment between components.
    - Vibration isolators, spring/pad type, quantity as recommended by the generator set manufacturer.

11. Building Ventilation
    - Provide properly sized combustion air, cooling air, exhaust air and re-circulating air dampers and louvres.
    - A standalone control system provides the damper actuator and temperature control requirements to work in conjunction with the engine-generator set.

Manufacturer:

- Engine generator shall be approved equal to Cummins G series (natural gas) or products with identical performance and rated characteristics as manufactured by Kohler.
- Automatic transfer switch shall be approved equal to Cummins OTPC Series or products with identical performance and rated characteristics as manufactured by Kohler.

Pump Starter Configuration Standards

Lift station pump control shall be provided by its starter in a separate control cabinet, MCC section or standalone combination motor starter. All required status and control elements are to be provided in the starter cabinet. If system parameters such as possible water hammer, electrical service or backup generation limitations or system configuration warrant it, the pump may be provided with a variable frequency drive. The pump starters are to conform to the following:

1. Magnetic and combination motor starters shall be NEMA standard, NEMA rated and shall be provided with the following:
    a. Electrically maintained contactors.
    b. Power and control terminal blocks with 10% spare (minimum of 2 spare terminals).
    c. Fused primary and secondary 120 Volt control transformers.
    d. Auxiliary isolated contactor and overload contacts.
    e. Solid-state intelligent overload protective device, with phase loss protection to provide tripping within three seconds with two poles energized at 115% of motor FLA, manually resettable from outside of the enclosure, provisions for a remote reset which can be added in future, and Modbus/TCP communications. Equal to Schneider TeSys series devices.
    f. Permanently secured copy of wiring and schematic diagrams inside the enclosure.
    g. Enclosures with hinged door shall be NEMA type as required by codes.
    h. Combination magnetic starters shall be provided with a magnetic circuit protector (MCP) type short circuit protective device. Individually enclosed combination motor starters are to be supplied and installed with a lock-off disconnecting device capable of being secured by a padlock.
    i. Ratings and pole configuration shall be as required.
    j. Auxiliary control and indication components shall be provided as required to provide interlocking and status to the PLC control system and may include the following:
        i. Hand-Off-Auto selector switch, NEMA Type 4 & 13, equal to Allen Bradley 800T Series or Schneider-Electric Harmony 9001K Series
        ii. Pump moisture / temperature protection relay(s), equal to Xylem MiniCAS II
        iii. On indicator light – Red – LED type, NEMA Type 4 & 13, equal to Allen Bradley 800T Series or Schneider-Electric Harmony 9001K Series.
        iv. Off indicator light – Green – LED type, NEMA Type 4 & 13, equal to Allen Bradley 800T Series or Schneider-Electric Harmony 9001K Series.

v. Alarm indicator light – Amber - LED type, NEMA Type 4 & 13, equal to Allen Bradley 800T Series or Schneider-Electric Harmony 9001K Series.

k. Magnetic motor starters to be approved equal to Allen Bradley Bulletin 513, Eaton Freedom ECN Series, Square D Class 8539 or Siemens Type ESP200 Series (NEMA/NEMA rated).

2. Variable Frequency Drive shall be provided with the following:
   a. Standard modes of operation: PID regulated, network reference, 4-20mA reference.
   b. Self-calibrating capable of adjusting itself for any line Voltage and frequency within its rating and any current value at or below continuous rating.
   c. Protective reactors on both line and load sides to protect power components from electrical transients.
   d. Energy saver option, which reduces motor power when the motor is lightly loaded.
   e. Protective fusing.
   f. Solid-state overload protective device, self-powered type, compensated for air temperature variations, with phase loss protection to provide tripping within three seconds with two poles energized at 115% of motor full load Amps, manually resettable from outside of the enclosure and provisions for a remote reset which can be added in future.
   g. Self-diagnostics shall include:
      i. Short Circuit
      ii. Overcurrent
      iii. IGBT Over-temperature Fault
      iv. Phase Loss
   h. Power and control terminal blocks with 10% spare or as indicated.
   i. Fused Primary and secondary, 120 V control transformer.
   j. Enclosures with hinged doors sealed by a gasket shall be NEMA Type as required by codes.
   k. VFDs shall be provided with a magnetic circuit protector (MCP) type short circuit protective device. Individually enclosed solid state motor starters are to be supplied and installed with a lock-off disconnecting device capable of being secured by a padlock.
   l. Ratings as required.
   m. Configurable Form C auxiliary contact.
   n. Auxiliary control and indication components shall be provided as required to provide interlocking and status to the PLC control system and may include the following:
      i. Hand-Off-Auto selector switch, NEMA Type 4 & 13, equal to Allen Bradley 800T Series or Schneider-Electric Harmony 9001K Series
      ii. Pump moisture / temperature protection relay(s)
      iii. On indicator light – Red – LED type, NEMA Type 4 & 13, equal to Allen Bradley 800T Series or Schneider-Electric Harmony 9001K Series.
      iv. Off indicator light – Green – LED type, NEMA Type 4 & 13, equal to Allen Bradley 800T Series or Schneider-Electric Harmony 9001K Series.
      v. Alarm indicator light – Amber - LED type, NEMA Type 4 & 13, equal to Allen Bradley 800T Series or Schneider-Electric Harmony 9001K Series.
   o. Variable Frequency Drive (VFD) shall be approved equal to the Schneider-Electric ATV600 series, with equivalent products from Toshiba, Allen-Bradley, Eaton, and Siemens.

3. Motor Control Center
    a. Motor Control Center (MCC) to be designed to incorporate components in vertical sections, 2286 mm high x 508 mm wide x 500 mm deep. All control and ancillary devices associated with one drive shall be installed in the unit compartment for that drive. Unused spaces shall be arranged to accommodate standard starter/feeder unit compartments in the future.
    b. MCCs shall be intelligent type incorporating devices to control motors, monitor their operation, monitor energy consumption, the quality of the energy and the functioning of the system, and communicate with the PLC or process control system through a self-contained data network.
    c. MCC operating Voltage, phase configuration and horizontal bus capacity shall be as required with vertical bus capacity as required for the units installed, but in no case less than 300 Amperes. Plated copper bus bars shall be barriered from unit compartments and braced for a minimum of 65,000 Amperes symmetrical.
    d. Wiring shall be NEMA Class 2 Type V with track-mounted terminals in each unit. Unit compartment wiring shall be number identified at all points of connection and termination. Numbers shall be identified on the drawing schematics and wiring diagrams for the unit compartment.
    e. Continuous horizontal wireways throughout the entire MCC length and intersecting vertical wireway in every section with separate doors.
    f. The structure shall be NEMA 1 gasketed with steel base channel and top and bottom cable/conduit entries and provisions for future add-on sections to both sides.
    g. Control units shall be a plug-in type with latching for two positions (engaged and withdrawn) and padlocking for the withdrawn position. Operator handle to be engaged with a disconnect at all times and interlocked with the hinged door.
    h. Motor starter units shall be a circuit breaker combination NEMA type or microprocessor-based power converters, sized and configured as required. The starter type, magnetic or microprocessor-controlled, shall be per those stated above.
    i. Feeder breaker units shall be mounted in unit compartments, and wherever possible dual compartments with individual hinged doors for each unit shall be used. Breaker shall be moulded case thermal-magnetic type sized and configured as required.
    j. Provide six (6) spare fuses and indicating lamps for each size and type used in the MCC.
    k. MCC shall be approved equal to Allen Bradley Centerline 2100, Eaton Freedom Series, Square D Model 6, or Siemens 8PX3.

Cable, Wire and Conduit Standards

1. Conductors
    a. Conductors to be copper and shall be insulated with RW90 cross-linked polyethylene insulation.
    b. Power conductors #12 AWG or larger to be stranded.
    c. All control and instrumentation conductors to be stranded and tin-plated.
    d. All new conductor joints and terminations shall be tin-plated to prevent corrosion. Every exposed bare copper conductor shall be tin-plated using resin-cored solder. The transition between the field tinning and conductor insulation shall be sprayed with a clear corrosion-inhibiting coating approved equal to Electricor.
    e. The minimum size for the power feeder and branch circuit conductors shall be #12 AWG. Conductors to be sized for Ampacity as per the Canadian Electrical Code and for

Voltage drop not to exceed 1.5% for a current flow equal to the circuit protection device's rating.

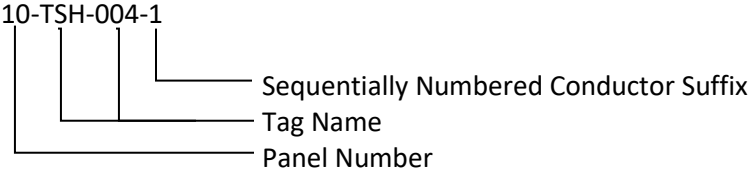
f. The minimum size for field control conductors shall be #14 AWG.
g. The minimum size for instrumentation conductors shall be #18 AWG.
h. Panel control wiring shall be minimum #16 AWG, type TEW, and minimum 26 strands tin-plated copper.

2. Raceway Systems – Conduits, Fittings & Grounding
    a. The minimum conduit size shall be 19 mm. Installed conduits to be sized as per the Canadian Electrical Code for all conductors which are to be installed.
    b. Rigid galvanized steel conduit (GRC) shall conform to CSA Standard C22.2 No. 45. Connectors and couplings to be liquid-tight, threaded steel type. Enclosure connectors to have nylon insulated throats and secured to enclosures with locknuts.
    c. Electrical metallic tubing (EMT) shall not be used in the lift stations.
    d. Rigid non-metallic conduit (PVC) shall conform to CSA Standard C22.2 No. 136. Connectors and coupling shall be threadless, solvent weld type, liquid-tight, and common manufacture with the PVC conduit. Continuous green insulated copper ground/bond conductor shall be installed in all PVC raceways bonding all electrical enclosures and utilization equipment.
    e. Liquid-tight PVC jacketed flexible conduit and connectors shall be used for all mechanical equipment and instrument connections.
    f. Due to humid conditions, rigid non-metallic conduit (PVC) is the preferred conduit system to be used in the lift stations.

3. Conductor Identification
    a. Conductor identification markers shall be proper sized with heat shrink wire markers with permanent black thermal printed mechanically reproduced characters. Alternative identification methods will not be considered.
    b. AC Power Conductors:
        i. All accessible branch circuit power conductors shall be individually identified, using conductor markers, which carry the source panel name and circuit number. Neutral conductors shall carry the source panel name and the single letter 'N.'
        ii. All accessible AC power conductors shall be colour-coded. Maintain existing phase sequence and colour coding throughout all power distribution systems.
            1. Phase A – Red
            2. Phase B – Black
            3. Phase C – Blue
            4. Neutral – White
            5. Ground (non-isolated) – Green
            6. Ground (isolated) – Green/Yellow
    c. DC Power Conductors:
        i. All DC power conductors are to be identified using conductor markers.
        ii. All DC power conductors shall be individually colour-coded. Maintain existing polarity and colour coding throughout all power distribution systems.
            1. Positive – Red
            2. Positive Switched – Orange
            3. Negative – Blue

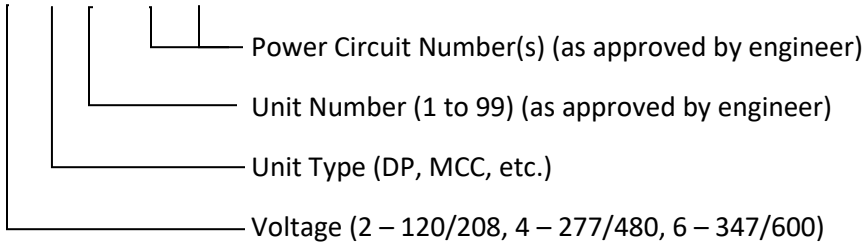
d. Instrumentation / Signal Conductors:
    i. All instrumentation, control, communication, data and alarm conductors shall be individually identified, using conductor markers, which carry the connected device's tag number along with a sequentially numbered conductor suffix. The site prefix number can be omitted as it is typically only used at the overall (SCADA) level.

EX: 10-TSH-004-1



4. Cable and Conduit Identification
    a. Every conduit and cable assembly shall be identified at the points from which it originates and terminates, including any intermediate intersecting box or panel and both sides of wall, floor or ceiling penetrations.
    b. Elliptical type marker and carrier strip fastened in two locations by a nylon tie-wrap. Markers to be flexible PVC with black characters on yellow background. Carrier strip to be black semi-rigid PVC and fastened with black self-locking tie-wrap.
    c. Markers, carriers and tie-wraps to be approved equal to Thomas & Betts SMS series complete with SMK markers and SMKH carriers.
    d. Power branch circuit conduits or cable assemblies to be identified as follows:
        i. Carry the source (system) identification, i.e. Voltage, Unit Type, Unit Number, plus all conductors within the conduit/cable.
        ii. Identification format to be:

P – X XXX XX – xx – xx



Control Equipment Standards

The following specifications are for the major instrumentation equipment required for the lift stations.

Control Panel

All Control panels are to be NEMA 12 rated for indoor installations and NEMA 4 rated for outdoor installations. The panels are to be complete with a 3-point latch and equipped with a pad-lockable hasp. Panels to be sized as required to incorporate the PLC or controllers, communication equipment, UPS system, receptacles, terminals, wire-ways, and if required, the panel heater. The panel is also to provide a 25% clear back-pan area for future expansion.

Field Communication

Communication to field devices, if not hard-wired, is to be by Ethernet, preferably in looped daisy-chain topology to provide redundant connection.

Level Transmitter

Level elements shall be rated for Class 1, Zone 1 installations.

Stand alone (monitoring stations): Ultrasonic level controller

- 24 VDC powered
- 4-20mA continuous level output
- 6 control/alarm contact option
- 6° beam angle with 15m range
- Approved equal to Siemens MultiRanger 100/200 complete with XPS-15 Transducer

Lift Stations (with PLC control): Ultrasonic level transmitter

- 24VDC loop powered
- 4-20mA continuous level output
- 10° beam angle with 12m range
- Approved equal to Siemens SITRANS Probe LU240

Lift Stations (with PLC control): Radar level transmitter

- 24VDC loop powered
- 4-20mA continuous level output
- Maximum 10° beam angle with 15m range
- Approved equal to VEGA VEGAPULS WL61

Lift Stations (with PLC control): Laser level transmitter

- 24VDC loop powered
- 4-20mA continuous level output
- 24VDC heated lens
- Maximum 0.5° beam angle with 100m range
- Approved equal to ABB LM80 series.

PLC Controller

The minimal system is to be based on Schneider Electric, EcoStruxure Control Expert (Unity Pro) compatible, PLC operating on 24 VDC and including the following:

- Processor/controller – M340 Series, model BMX P34 2020 (Ethernet)
- Expansion rack as required to have two (2) free slots – model BMX XBP XXX
- 24 VDC discrete input card – model BMX DDI 1602 (16 point 24VDC)

Additional I/O cards to be provided as required and be based on the following:

- 24 VDC discrete input card – model BMX DDI 1602 (16 point 24VDC)
- 24 VDC discrete input card – model BMX DDI 3202K (32 point 24VDC)

- 120 VAC discrete input card – model BMX DDI 1604 (16 point 100-120VAC)
- Discrete output card – model BMX DRA 1605 (16 point 24VDC, 24-240VAC)
- Analog input card – model BMX AMI 0810 (8 point 4-20mA input)
- Analog output card – model BMX AMO 0410 (4 point 4-20mA output)

The following PLC registers will be reserved for SCADA communication as outlined below, with final mapping approved by the City:

- Real-time Clock %MW1 to %MW10
- Discrete status to HMI %MW500 to %MW509
- Analog status to HMI %MW510 to %MW599
- Discrete status from HMI %MW600 to %MW609
- Analog status from HMI %MW610 to %MW699

H2S Detection

The H_2S detection system for wastewater lift stations must be complete with a sensor/transmitter wired to a dual-channel controller. The controller is to be complete with a strobe light visible upon entry to the lift station, activated by a high-level condition. The controller to provide dry contact outputs on high and high-high level conditions. H_2S controller to be MSA Ultima X Series.

Flow Transmitter

A flow transmitter is to be provided in wastewater lift stations where piping arrangements allow for proper installation. A magnetic flow meter is recommended to be installed, complete with bypass piping or replacement sleeve. The flow meter is to be approved equal to ABB magnetic flow meter complete with remote electronic transmitter/integrator unit, 120 VAC power, 4-20mA output and totalizer pulse output.

Pressure Transmitter

A pressure transmitter is to be provided in lift stations where a domestic potable water supply is provided. The pressure transmitter is to be approved equal to the Schneider XMLP100 series, complete with stainless water connection suitable for potable use, 24VDC loop power, and 4-20mA analog output.

DC UPS System

Wherever possible, a 24 VDC UPS system is to be installed at all sites that have the level transmitters, controllers and communication equipment powered by the DC power supply. The DC UPS system batteries are to support the control equipment for a minimum of 2 hours during a power failure. The DC UPS system is to be complete with a charging unit, gel cell batteries and two pole battery disconnect breaker; it will be approved equal to Phoenix Contact Quint DC UPS Series or Weidmuller CP DC UPS Series.

Communication Modem

The communication system comprises either an industrial-grade serial radio, ethernet radio, or LTE data radio. Provide and install approved polyphasers (surge protectors), full-band bandpass filters, and antennae appropriate to the frequencies in use. The City shall provide radios. The City shall advise frequencies.

Wireless I/O

In circumstances where a signal must be relayed from a distance, and a direct cable connection is not practicable, a radio unit may be used to receive/transmit discrete and analog signals. The wireless I/O shall be the Phoenix Contact Radioline series. Wireless I/O systems shall be provided with approved polyphasers, full-band bandpass filters, and antennae appropriate to the frequencies in use.

Wetwell Float Switches

The float switch shall be mercury-free, SPDT mechanical switch type. Float casing of polypropylene, bending relief of EPDM rubber, 3C #19 AWG cable of special compound PVC, level regulator hanger bracket and sway control ring (or stilling well). All wiring connections to be accessible outside of the wet well. The float switch to be equal to Xylem #ENM-10 switch, Xylem #13-520006 regulator hanger bracket, and Xylem #13-507006 sway control ring. Intrinsically safe signal barriers shall be employed at all wastewater lift stations.

Lift Station Flood Switches

Flood switch shall be single point action (15W contact, normally open – closes on the level rise of liquid with a specific gravity of 0.8) level switch with slosh guard, wall mounting bracket and 1800 mm long waterproof lead wire. The float is to be mounted 50 mm above floor level, and the float switch to be approved equal to Gems LS-270 Series.

Temperature Switches

Temperature switch shall be suitable for sensing the ambient air temperature, direct vertical immersion type. The snap switch shall be a form C contact rated at 5A at 120 VAC, 1.0 HP at 240 VAC. Enclosure to be NEMA 4 rated, wall mounted with 12 mm conduit connection. The temperature switch to be approved equal to Allen Bradley 837-V1J.

Door Monitoring Switches

Door Switch shall be adjustable top push rod, spring return, sealed contact limit switch, complete with normally open contact. The limit switch to be approved equal to Allen Bradley 802R-BAF Series.

Air Flow Switches

Airflow switch shall be suitable for duct air proving, differential pressure switch with a fixed dead-band adjustable set-point range of 0.012 to 1/24 kPa, scale plate, SPDT switch and mounting bracket and any required sensing tubing. The flow switch to be approved equal to Johnson Controls P32 Series.

Fire Alarm Initiation Device

The heat detector shall be plug-in-type mounting with an interchangeable detector. The detector shall be a combination rate-of-rise and fixed temperature operation. The unit is to be complete with a single Form A contact and LED alarm operation indicator.

Control Relays

Control relays shall be a plug-in, encapsulated type complete with 3 Form C contacts rated at 10A, 120 VAC, and internal LED pilot indicators. Coil Voltage shall be as indicated or required. Relays to be approved equal to Potter & Brumfield KRP/KRPA series or OMRON MK series, with hold-down clips.

Voltage sensing relays shall be separately adjustable pickup and dropout type with no time delay complete with 2 Form C contacts rated at 10A, 24 VCD. Coil Voltage to be as indicated (24 VDC or 120 VAC). Relays to be approved equal to Potter & Brumfield CS series.

Timers

Timers shall be solid-state, multiple ranges, programmable operation, plug-in encapsulated assembly. Timer operating configuration shall be selectable (4 operating modes) and set as required. Minimum of 2 Form C contacts shall be rated for 5A, 250 VAC. Supply Voltage shall be as indicated or required. Timer relays shall be OMRON Series H3CR.

Terminal Blocks

Terminal blocks shall be push-in type, complete with mounting rails or channels, provided for connection to field device wiring. Terminals shall be easily accessible for attachment of field connections and shall be physically grouped according to the type of circuit (digital, analog, input, output, AC, DC, etc.) and Voltage. Analog and communication terminals shall be located as far as practical from all power terminals. Each terminal shall be identified with the number as indicated. Each field connecting conductor shall be served by one terminal. Provide ten percent spare terminals for each grouping employed in the panel. Use double high terminals where practicable. Terminal blocks shall be approved equal to Weidmuller A-series or Phoenix Contact PTV series.

Pushbuttons, Selector Switches and Pilot Lights

Pushbuttons and control switches shall be heavy-duty, watertight/oil-tight NEMA Type 4 with multi-element stackable contact blocks and side wired screw terminals. Contact arrangements and configurations shall be as indicated. Unless indicated otherwise, pushbutton operators shall be momentary contact type, flush head construction and black. Contact rating to be AC=AC600 and DC=P600 unless otherwise specified. Unless indicated otherwise, rotary operators shall be three-position, maintained contact. Contact rating to be AC=AC600 and DC=P600 unless otherwise specified. Indicating lights shall be heavy-duty, watertight/oil-tight NEMA Type 4 with back-mounted screw terminals for operation at Voltages as indicated. Indication light lenses shall be coloured as indicated and shall be removable from the front for lamp replacement. Lamps shall be LED type unless otherwise indicated. Pushbuttons, control switches and indicating lights to be NEMA Type 4, approved equal to Allen Bradley 800T Series or Schneider-Electric Harmony 9001K Series.

Human/Machine Interface

Human/machine interface (HMI) shall be touch screen type complete with minimum 177mm (7”) colour graphical screen, Ethernet-based communications, real-time clock, and USB ports for programming, storage and data connections. HMI units shall be the Red Lion Graphite series.

Tagging Structure

The field instruments' tagging will be as indicated on the loop drawings and will follow the ANSI/ISA-5.1 standard for Instrumentation Symbols and Identification.

Ex: xxxx-yyyz

- Equipment number suffix is used for multiple devices with the same equipment and shall follow an alphabetic sequence (A, B, C, etc.)
- Equipment Number – use three digits.
- Equipment Type – up to 4 digits as required per ANSI Designation (P, ZSC, FIT, LSHH, etc.)

The following table lists typical tagging to be used for lift stations (pump-related tags are to be in the hundred series with the hundred's digit representing the pump number):

Point Description	Typical Tag
Electric Pump Run Status	YI-210
Electric Pump Available Status	YY-210
Electric Pump Auto Switch Status	HSA-210
Electric Pump Not In Auto Alarm	HAA-210
Electric Pump Fault Status	UA-210
Electric Pump Moisture Switch Status	MSH-210
Electric Pump Moisture Alarm	MAH-210
Electric Pump Temperature Switch Status	TSH-210
Electric Pump Temperature Alarm	TAH-210
Electric Pump Run Control	XC-210
Electric Pump Elapsed Run Time	KQI-210
Electric Pump Start Counter	XQI-210
Engine Pump Run Status	YI-211
Engine Pump Auto Switch Status	HSA-211
Engine Pump Not In Auto Alarm	HAA-211
Engine Pump Fault Status	UA-211
Engine Pump Run Control	XC-211
Engine Pump Elapsed Run Time	KQI-211
Engine Pump Start Counter	XQI-211
Wet Well High High-Level Float Switch	LSHH-200
Wet Well High High-Level Alarm	LAHH-200
Wet Well Low Low-Level Float Switch	LSLL-200
Wet Well Level Transmitter	LIT-200
Wet Well Level Transmitter Fault Alarm	LAT-200
Wet Well Level Transmitter Loss of Echo	LAE-200
Ancillary Level Transmitter	LIT-400
Dry Well Flood Float Switch	LSHH-002
Dry Well Flood Alarm	LAHH-002
UPS System Alarm	EAL-903
Utility Power Fail	EAL-901
Transfer Switch on Utility	ZS-910A
Transfer Switch on Generator	ZS-910B
Generator Fault Status	UA-902
Building/Panel Security Switches	ZSO-100
Building Fire	TKSH-107
Building/Panel Low-Temperature Switch	TSL-104

Building/Panel Low-Temperature Alarm	TAL-104
Building/Panel High-Temperature Switch	TSH-104
Building/Panel High-Temperature Alarm	TAH-104
High H2S Switch Status	ASH-012
High H2S Alarm	AAH-012
Ventilation Flow Switch	FSL-013
Ventilation Failure Alarm	FAL-013
Flow Rate	FI-210
Flow Totalization	FQI-210
Potable Water Pressure Transmitter	PIT-800

PLC Configuration

Programming Software

Schneider-Electric EcoStruxure Control Expert (Unity Pro), IEC Programming Software for Modicon PACs, will be used for lift station controllers. It shall be used for developing, testing, monitoring, documenting, and printing the PLC programs.

Program Structure

The programming will be developed using a function block diagram (unless there is demonstrated reason to use one of the other IEC61131-3 languages). Wherever possible FDT-DTM device drivers shall be used to interface to field devices. Each section of the program will be given a title describing its function. The major sections in the PLC program will include the following:

- Analog input configuration and scaling
- Discrete input conditioning and linking
- Flow rate and pumped volume calculation
- Pump sequencing logic (Pump lead/lag logic with alternating control as required)
- The pump control logic (complete with a number of start counter and run timer)
- Entry monitoring
- Alarms
- SCADA data preparation

The status of discrete inputs to the PLC is such that a logic “1” is the “ON” status. Many field devices are wired for the fail-safe operation to the PLC. Therefore, for protective alarm points, the normal input status will be "ON," and the alarm state will be indicated by an opened loop or when the device is de-energized. The alarm logic will be conditioned such that the alarm state is a logic "1".

Whenever possible, all the analog information used in the PLC will be in floating-point format. Therefore, all analog inputs will be converted from the raw integer values to engineering units using floating-point math. Similarly, all variables destined for analog output will be calculated using floating-point engineering units, then converted to the raw integer value to correspond with the output card requirements.

Lift station outlet flow rates will be based on flow meter analog signals, and the pumped volume will be based on the meters’ totalizer pulse signals to the PLC. For sites without flow meters, the lift station outlet flow rates will be based on the pump curves and the number of pumps running, while the pumped volume will be based on the calculated flow rates multiplied by the pump run times.

Unless otherwise dictated by pump sizing or configuration, pumps will be operated based on lead/lag sequencing logic with automatic alternation between the pumps for lead status on shut down of all the pumps. Once started, the lag pumps will continue to run until the stop level is reached. If selected as the lead pump, any condition that renders that pump unavailable will automatically cause the lead status to toggle to the next available pump.

Every site will be equipped with entry monitoring systems. Systems will consist of limit switches located on the building doors or panel doors and an audible horn. The audible horn will be activated to ward off any unauthorized intruder on activation of a limit switch (wired normally closed for failsafe operation). To acknowledge and silence the audible horn, the limit switch is operated two or more times within a 30-second time frame; otherwise, an intrusion alarm will be activated. Once acknowledged, the system will reactivate itself after a 30-minute time delay.

Program Documentation

All PLC programs are to be fully documented using the documentation tools provided within the programming software. The documentation shall include database tags, tag descriptors and comments within the logic sections and function block diagrams.

Variable tags used in the program shall follow the instruments' tagging as provided on the loop drawings and as outlined previously. For those internal variables that do not follow the instrument tagging scheme, the tag should indicate the variable's function. Tags shall be in capital/uppercase letters. Variable tags shall be provided with descriptive comments to explain the function of said variables further.

The PLC program will include descriptions of the areas and functions provided by the program sections. The description shall be part of the section description and entered in paragraph form.

Human/Machine Interface Configuration

Configuration Software

HMI units shall be programmed using Crimson configuration software from Red Lion. A copy of the final configuration file shall be provided to the City as part of the final station documentation.

Instrumentation Configurations

All Stations - Instrumentation

All configurations shall be recorded and provided as part of the Operations & Maintenance (O&M) Manuals. O&M Manuals shall form part of the substantial completion package.

SCADA Communication Network

The lift stations' communication will be master/slave polling using Modbus or Modbus/TCP remote communication via radio communications as identified above. The SCADA computer will be configured to poll the lift station controllers. Modbus station addresses will be assigned by the City as needed. Generally, addresses 10-49 are reserved for storm lift stations, and 50-99 are reserved for domestic lift stations. The City shall implement all SCADA configurations to incorporate new installations.