

COMMON WORK RESULTS FOR ELECTRICAL

1. GENERAL

1.1 References

- .1 Canadian Standards Association (CSA):
 - .1 CSA C22.1, Canadian Electrical Code, Part 1), Safety Standard for Electrical Installations.
 - .2 CSA C22.3 No.7, Underground Systems.
 - .3 CAN/CSA-C22.3 No. 1, Overhead Systems.
 - .4 CAN3-C235, Preferred Voltage Levels for AC Systems, 0 to 50,000 V.
- .2 Institute of Electrical and Electronics Engineers (IEEE):
 - .1 IEEE 100, The Authoritative Dictionary of IEEE Standards Terms.
- .3 City of Winnipeg:
 - .1 Identification Standard
 - .2 Electrical Design Guide

1.2 Definitions

- .1 Electrical and electronic terms: unless otherwise specified or indicated, terms used in these Contract Documents, are those defined by IEEE 100.

1.3 General Requirements

- .1 Refer to Specifications for General Requirements related to the Contract Documents.
- .2 Refer to Division 40 for process and instrumentation work related to the electrical installation.
- .3 Refer to Division 26 for finishes related to electrical installation.
- .4 Refer to P&ID and Process Mechanical drawings for more information about the electrical systems interconnection requirements.
- .5 Refer to all Sections of Division 26 and Drawings.
 - .1 The intent of the Specifications and Drawings is to include all labour, products, and services necessary for complete Work, tested and ready for operation.
 - .2 Symbols used to represent various electrical devices often occupy more space on the Drawing than the actual device does when installed. In such instances, do not scale locations of devices from electrical symbols. Install these devices with primary regard for usage of wall space, convenience of operation and grouping of devices. Refer to installation details where they exist.

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- .3 Responsibility to determine which Division provides various products and work rests with the Contractor. Additional compensation will not be considered because of differences in interpretation of the present specifications.

1.4 Design Requirements

- .1 Operating voltages: to CAN3-C235.
- .2 Motors, electric heating, control and distribution devices and equipment to operate satisfactorily at 60 Hz within normal operating limits established by above standard.
 - .1 Equipment to operate in extreme operating conditions established in above standard without damage to equipment.
- .3 Language operating requirements: provide identification nameplates and labels for control items in English.

1.5 Submittals

- .1 Submittals: in accordance with Specification E6.
- .2 Shop Drawings:
 - .1 In accordance with Specification E6.
 - .2 Submit wiring diagrams and installation details of equipment indicating proposed location, layout and arrangement, control panels, accessories, piping, ductwork, and other items that must be shown to ensure coordinated installation.
 - .3 Identify on wiring diagrams circuit terminals and indicate internal wiring for each item of equipment and interconnection between each item of equipment.
 - .4 Indicate on Contract Document clearances for operation, maintenance, and replacement of operating equipment devices.
 - .5 If changes are required, notify Contract Administrator of these changes before they are made.
 - .6 Contract Administrator will not assume the responsibility for searching out deviations in the Contractor drawings.
 - .7 Shop drawings shall be first checked by the Contractor for space, dimension, performance characteristics and general conformance to the Drawings and Specifications and shall be so stamped. Shop Drawings not stamped as specified will be returned to Contractor without action. Contractor's stamp shall include name and address of Contractor, the date checked, the initials of the checker and the status of the checking, including conclusive mark-ups.
 - .8 Shop Drawings shall include manufacturer's name and address, equipment or material descriptive names, and catalog number. Shop Drawings shall indicate dimensions, voltage and current characteristics, wire sizes, test or conformance data, construction and rough-in data of all material to be used.

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- .9 Submit only shop drawing documentation relevant to the product supplied and clearly marked as such. Entire catalog sections lacking clear indication of the relevant documentation will be rejected.
- .10 Submit Shop Drawings and/or product literature for system components as called below, but not limited to:
 - .1 Cables & Accessories.
 - .2 Cable Trays, & Installation Accessories.
 - .3 Power Circuit Breakers. (PCB).
 - .4 Molded Case Circuit Breakers. (MCCB).
 - .5 Safety Disconnect Switches. (DS).
 - .6 Motor Control Centers.
 - .7 All type of starters; FVR, FVNR, VFD's & RVSS.
 - .8 Panelboards and Accessories.
 - .9 Lighting Fixtures, Lighting Controls & Accessories.
 - .10 Emergency lighting.
 - .11 Switches, Receptacles, Heavy Duty Receptacles & Power connectors.
 - .12 Equipment Cabinets, Racks & Consoles.
 - .13 Control and Smart Relays.
 - .14 Terminal and Wire Marking System.
 - .15 Lightning and Surge Protectors.
 - .16 Power Metering and Monitoring.
- .3 Testing:
 - .1 Check resistance to ground before energizing. Submit ground resistivity measurement study.
- .4 Quality Control:
 - .1 Provide CSA certified equipment and material. Where CSA certified equipment and material is not available, submit such equipment and material inspection authorities for special acceptance approval before delivery to Site.
 - .2 Submit test results of installed electrical systems and instrumentation.
 - .3 Permits and fees: in accordance with General Conditions of Contract.

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- .5 Submit, upon completion of Work, load balance report as described in Part 3.19.1 - The Contractor shall conduct and pay for tests as identified in part 3.19.6 below.
- .6 Provide a manufacturer's certificate or letter confirming that the entire installation as it pertains to each system had been installed in accordance with the manufacturers' instructions.
- .7 Carry out tests in presence of the Contract Administrator or City Representative.
- .8 Ground fault detectors shall be dynamically tested by injecting current flow into the zero sequence current sensor.
- .9 Submit test results for Contract Administrator's review.
- .1 .
- .2 Submit certificate of acceptance from Authority Having Jurisdiction upon completion of Work to Contract Administrator.

1.6 Manufacturer's Field Reports: submit to Contract Administrator Manufacturer's written report, within three (3) days of review, verifying compliance of Work and electrical system and instrumentation testing, as described in Part 3.14 - Separation of Services

- .1 Maintain separation between electrical wiring system and piping, ductwork, etc. so that wiring system is isolated (except at approved connections to such systems) to prevent galvanic corrosion.
- .2 In particular, contact between dissimilar metals, such as copper and aluminum, in damp or wet locations is not permitted.
- .3 Do not support wiring from pipes, ductwork, etc.

1.7 Mounting Heights

- .1 Mounting height of equipment is from finished floor to centreline of equipment unless specified or indicated otherwise.
- .2 If mounting height of equipment is not specified or indicated, verify before proceeding with installation. Install electrical equipment at following heights unless indicated otherwise.
 - .1 Local switches: 1400 mm.
 - .2 Wall receptacles:
 - .1 General: 300 mm.
 - .2 In mechanical rooms: 1400 mm.
 - .3 In wet or outdoor locations: minimum 1000 mm above finished grade/floor.
 - .3 Panelboards: as required by Code or as indicated.
 - .4 Telephone and LAN outlets:

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- .1 General: 300 mm.
- .2 Above top of counters or desk: 175 mm.

1.8 Location of Equipment

- .1 Examine and study the Architectural, Structural and Mechanical drawings for items affecting the installation of the Work under this specification and locate conduit runs, pull and junction boxes, disconnects, controlled equipment and panels accordingly and such that working clearances and maximum ceiling heights can be maintained, and to avoid conflict with other installations.
- .2 Any device, panel or equipment which is miss-located as a result of failure to observe the foregoing instructions shall be relocated without extra cost.
- .3 If a specific equipment location is in question, request directions from the Contract Administrator.

1.9 Alignment of Electrical Components

- .1 Where there are two (2) or more equipment items (switches, outlets, panels or related equipment) are installed together, they shall be aligned vertically and/or horizontally to present a neat orderly appearance.
- .2 They shall also be aligned and symmetrical with architectural elements.

1.10 Accessibility

- .1 Install all Work to be readily accessible for adjustment, operation and maintenance.
- .2 Install all devices and protective systems to be accessible as per CEC (latest revision requirements).
- .3 Field Quality Control.
- .4 Drawings of Record:
 - .1 One (1) complete set of construction drawings shall be kept on Site. Records during construction will be maintained.

1.11 Quality Assurance

- .1 Qualifications: electrical Work to be carried out by qualified, licensed electricians who hold valid license in accordance with Authorities Having Jurisdiction.
 - .1 Employees registered in provincial apprenticeship program: permitted, under direct supervision of qualified licensed electrician, to perform specific tasks.
 - .2 Permitted activities: determined based on training level attained and demonstration of ability to perform specific duties.

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1.12 Delivery, Storage, and Handling

- .1 Material Delivery Schedule: Provide Contract Administrator with schedule within two (2) weeks after award of Contract.

1.13 Waste Management and Disposal

- .1 Separate waste materials for reuse and recycling.
- .2 Collect and separate paper, plastic, polystyrene and corrugated cardboard packaging material for recycling.
- .3 Divert unused metal and wiring materials from landfill to metal recycling facility as approved by Contract Administrator.
- .4 Fold up metal banding, flatten and place in designated area for recycling.
- .5 Remove from site and dispose of all packaging materials at appropriate recycling facilities.
- .6 Place materials defined as hazardous or toxic waste in designated containers.
- .7 Ensure emptied containers are sealed and stored safely for disposal away from children and wildlife.
- .8 Unused sealant material must not be disposed of into sewer system, streams, lakes, onto ground or in other locations where it will pose health or environmental hazard.
- .9 Do not dispose of preservative treated wood through incineration.
- .10 Do not dispose of preservative treated wood with other materials destined for recycling or reuse.
- .11 Dispose of treated wood, end pieces, wood scraps, and sawdust at a sanitary landfill approved by Contract Administrator.

1.14 System Start-up

- .1 Instruct Contract Administrator and operating personnel in operation, care and maintenance of systems, system equipment and components.
- .2 Arrange and pay for services of Manufacturer's factory service Engineer to supervise start-up of installation, check, adjust, balance and calibrate components and instruct operating personnel.
- .3 Arrange and pay for services of an instrumentation technician to check, adjust, balance and calibrate components and instruct operating personnel.
- .4 Provide these services for such period, and for as many visits as necessary to put equipment in operation, and ensure that operating personnel are conversant with aspects of its care and operation.

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1.15 Operating Instructions

- .1 Provide for each system and principal item of equipment as specified in technical sections for use by operation and maintenance personnel.
- .2 Operating instructions to include following:
 - .1 Wiring diagrams, control diagrams, and control sequence for each principal system and item of equipment.
 - .2 Service instructions: including a list of spare parts and replacement parts and the names and addresses of all suppliers.
 - .3 Maintenance instructions: including start-up, proper adjustment, operating, lubrication, and shutdown procedures.
 - .4 Installation instructions.
 - .5 Safety precautions.
 - .6 Operating instructions, including procedures to be followed in event of equipment failure.
 - .7 Other items of instruction as recommended by Manufacturer of each system or item of equipment.
- .3 Print or engrave operating instructions and frame under glass or in approved laminated plastic.
- .4 Post instructions where directed.
- .5 For operating instructions exposed to weather, provide weather-resistant materials or weatherproof enclosures.
- .6 Ensure operating instructions will not fade when exposed to sunlight and are secured to prevent easy removal or peeling.

1.16 Compliance

- .1 Failure to comply with the drawings and specifications shall be cause for rejection and the Contractor shall be required to make good at no additional cost to the City or their agents.

2. PRODUCTS

2.1 Materials and Equipment

- .1 Provide materials and equipment.
- .2 All equipment shall be manufactured by experienced manufacturers who can demonstrate in-use records for all equipment offered.
- .3 Where there are multiple instances of similar equipment, they shall be all by the same manufacturer.

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- .4 Requests for approval of alternative suppliers shall be submitted to the Contract Administrator prior to tender closing.
- .5 Material and equipment to be CSA Certified. Where CSA Certified material and equipment are not available, obtain special approval from inspection authorities before delivery to site and submit such approval as described in Specification E6..
- .6 Factory assemble control panels and component assemblies.

2.2 Electric Motors, Equipment and Controls

- .1 Verify installation and co-ordination responsibilities related to motors, equipment and controls, as indicated.
- .2 Control wiring and conduit: in accordance with Division 26 05 21 - Wire and Cables (0-1000V) and Division 26 05 34 - Conduits, Conduit Fastenings and Conduit Fittings.

2.3 Warning Signs

- .1 Warning Signs: in accordance with requirements of Authority Having Jurisdiction, inspection authorities, and Contract Administrator.
- .2 Lamacoid, red with white lettering, minimum size 175 x 250 mm.

2.4 Wiring Terminations

- .1 Ensure lugs, terminals, screws used for termination of wiring are suitable for either copper or aluminum conductors.
- .2 Lugs, connectors, or any other termination devices shall be rated for 75°C.

2.5 Equipment Identification

- .1 Identify electrical equipment and devices with nameplates as follows:
 - .1 Nameplates: lamicaid 3 mm thick plastic engraving sheet, black face, white core, lettering accurately aligned and engraved into core mechanically attached with self-tapping screws.
 - .2 Sizes as follows:

NAMEPLATE SIZES

Size 1	10 x 50 mm	1 line	3 mm high letters
Size 2	12 x 70 mm	1 line	5 mm high letters
Size 3	12 x 70 mm	2 lines	3 mm high letters
Size 4	20 x 90 mm	1 line	8 mm high letters
Size 5	20 x 90 mm	2 lines	5 mm high letters
Size 6	25 x 100 mm	1 line	12 mm high letters
Size 7	25 x 100 mm	2 lines	6 mm high letters

- .2 Labels: embossed plastic labels with 6 mm high letters unless specified otherwise.
- .3 Wording on nameplates and labels to be approved by Contract Administrator prior to manufacture.

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- .4 Allow for minimum of twenty-five (25) letters per nameplate and label.
- .5 Nameplates for terminal cabinets and junction boxes to indicate system and/or voltage characteristics.
- .6 Disconnects, starters and contactors: indicate equipment being controlled and voltage.
- .7 Terminal cabinets and pull boxes: indicate system and voltage.
- .8 Transformers: indicate capacity, primary and secondary voltages.
- .9 All distributions, panelboard, transfer switches, MCC's, Splitters, transformers, VFD's, reactors, filters, etc. provide circuit panel designations and where fed from.

2.6 Wiring Identification

- .1 Identify wiring with permanent indelible identifying markings, either numbered or coloured plastic tapes, on both ends of phase conductors of feeders, branch circuit wiring and neutrals.
- .2 Maintain phase sequence and colour coding throughout.
- .3 Colour coding: to CSA C22.1.
- .4 Use colour coded wires in communication cables, matched throughout system.

2.7 Conduit and Cable Identification

- .1 Colour code conduits, boxes and metallic sheathed cables.
- .2 Code with plastic tape or paint at points where conduit or cable enters wall, ceiling, or floor, and at 15 m intervals.
- .3 Colours: 25 mm wide prime colour and 20 mm wide auxiliary colour.

	Prime	Auxiliary
Up to 600V	Orange	Green
Up to 250 V	Yellow	
Telephone/LAN	Green	
Other Communication Systems	Green	Blue
Fire Alarm	Red	

2.8 Finishes

- .1 Shop finish metal enclosure surfaces by application of rust resistant primer inside and outside, and at least two (2) coats of finish enamel.
 - .1 Paint outdoor electrical equipment light gray finish.
 - .2 Paint indoor switchgear and distribution enclosures light gray to EEMAC 2Y-1.

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3. EXECUTION

3.1 Installation

- .1 The complete installation shall be carried out in accordance with the latest CSA C22.1 - Canadian Electrical Code, except where specified otherwise.
- .2 Do overhead and underground systems in accordance with CSA C22.3 No.1 except where specified otherwise.
- .3 All work shall be executed in accordance with the latest current codes, standards, statutes or recommendations of the following technical societies, trade organizations, and governing agencies, and shall be subject to the inspection of those departments having jurisdiction.
- .4 Install all equipment in accordance with the manufacturer's recommendations and in a manner that will ensure satisfactory operation upon completion.
- .5 Provide all labour and all necessary equipment including lifts, scaffolding, tools and rigging materials for installation of the equipment.
- .6 The Contractor shall be responsible for coordinating all mechanical, instrumentation and other works for the equipment being installed.
- .7 No Work shall commence without the appropriate permits from the Authority Having Jurisdiction.

3.2 Workmanship

- .1 Workmanship shall be the best quality, executed by workers qualified to do electrical work as defined in Section 1.11 Quality Assurance.
- .2 Qualified tradesman shall be used for the transformer and switchgear installation and all cable installation and terminations.
- .3 The Contract Administrator reserves the right to require the dismissal from the Site of workers deemed incompetent.
- .4 The Contract Administrator reserves the right to require the proof of competency for the site superintendent, project coordinator, data and fiber installer and cable termination electricians. The Contract Administrator reserves the right to dismissal from Site of workers deemed incompetent. The Contractor is responsible to ensure the proper competencies for the Work performed.
- .5 In cases of dispute, decisions as to the quality, fitness or workmanship rest solely with the Contract Administrator, whose decision is final.
- .6 If any of the work is such as to make it impractical to produce required results, immediately notify the Contract Administrator.
- .7 All exposed parts of the electrical wiring systems such as exposed conduits, flush plates, cabinet trim, fixtures, etc., shall be square and true with the building construction.

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3.3 Drawings and Specifications

- .1 The Drawings and Specifications shall be used together, and all materials and labor mentioned in one but omitted from the other shall be considered as sufficiently specified and shall therefore be supplied and installed.
- .2 The location of various items on the drawings is approximate, unless specified otherwise, and is subject to slight revisions as the work is installed in order to accommodate construction conditions.
- .3 Where equipment and material dimensions are dependent upon building dimensions take field measurements, do not scale the drawings.
- .4 The construction drawings are not intended to be scaled for roughing-in measurements nor to serve as Shop Drawings.
- .5 The Contractor shall consult the structural, mechanical, or equipment drawings for dimensions, obstructions, and location of equipment of other trades. Any discrepancies between architectural, structural, mechanical, or equipment drawings and the work shown on the electrical drawings shall be reported to the Contract Administrator for adjustment.
- .6 The installation details, instructions, and recommendations of the manufacturer of the product used, or modified to obtain the best end result, shall be the basis of attaining installation of the products for usage on this project except where definite and specific instructions are set forth herein or details are shown on the Drawings.
- .7 Outlet devices, switches, panels, cabinets, fixtures and special equipment are shown on the drawings only in a schematic manner and not necessarily in their specific location. The Contractor shall be responsible for exact locations of the outlets to form a functional and aesthetic installation either by careful review of all architectural elevations, tile patterns, surface finishes, and equipment arrangements or by consultation with the Contract Administrator and other trades involved.

3.4 Errors and Omissions

- .1 In the event of errors or discrepancies between the Drawings, City of Winnipeg Design Guides, and Specifications, the Contractor shall obtain a ruling before Tenders are submitted.
- .2 If a ruling has not been requested, it shall be assumed that in event of a discrepancy, the Contractor has allowed for the more expensive alternative.
- .3 Where the Authority Having Jurisdiction has indicated that changes are required which will cause delay and/or additional costs, the Contractor shall notify the Contract Administrator of the proposed changes as soon as practicable.

3.5 As-Built Drawings

- .1 The Contractor is required to keep current a marked-up set of drawings recording all modifications to the electrical equipment on site and upon request provide to the Contract Administrator for review.
- .2 After commissioning the Contractor shall transfer all changes to a single set of drawings.

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- .3 Obtain a CAD set of drawings (wiring & control diagrams) from the Contract Administrator and use professional services for CAD and transfer the "As-Built" condition for all components on those drawings.
- .4 No Substantial Performance shall be issued until final "Record Drawing" CAD files and one set of prints have been received and accepted by the Contract Administrator.

3.6 Grounding

- .1 All circuits shall be installed with dedicated green insulated ground wire.

3.7 Dedicated Neutrals

- .1 Each circuit shall have its own dedicated neutral wire. Shared neutral for more than 1 circuit shall not be permitted.

3.8 Area Category and Classifications

- .1 The Pump Station area has the following electrical categories and classifications as defined in the CEC:
 - .1 Lift Station Wet Well: Category 2, Zone 2, Group IIA and IIB

3.9 Enclosures

- .1 Dry/General NEMA 1
- .2 Wet/Outdoor/Corrosive/Category 1 or Category 2 NEMA 4X
- .3 Hazardous Rated for hazardous location and gases present

3.10 Nameplates and Labels

- .1 Ensure Manufacturer's nameplates, CSA labels and identification nameplates are visible and legible after equipment is installed.

3.11 Conduit and Cable Installation

- .1 Install conduit and sleeves prior to pouring of concrete.
 - .1 Sleeves through concrete: schedule 40, sized for free passage of cabling and protruding 100 mm.
- .2 If plastic sleeves are used in fire rated walls or floors, remove before conduit installation.
- .3 Install cables, conduits and fittings embedded or plastered over, close to building structure so furring can be kept to minimum.
- .4 Do not mix wiring and/or cables from different panels within the same conduit runs or pull boxes. Provide equipment barriers where acceptable and where applicable.

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3.12 Sleeves

- .1 Provide sleeves of galvanized steel pipe with machine cut ends of ample size to accommodate conduits passing through walls, partitions, ceilings, floors, etc.
- .2 For wall, partitions and ceilings the ends shall be flush with the finish on both sides but for floors they shall extend 4" above finished floor level.
- .3 The space between the sleeve and the conduit shall be fire stopped caulked around the top and bottom with approved permanently resilient, non-flammable and weatherproof silicone base compound and ensure that the seal is compatible with the floor and ceiling finishes.
- .4 Locate and position sleeves exactly prior to construction of walls, floors.

3.13 Coordination of Protective Devices

- .1 Ensure circuit protective devices such as overcurrent trips, relays and fuses are installed to required values and settings.

3.14 Separation of Services

- .1 Maintain separation between electrical wiring system and piping, ductwork, etc. so that wiring system is isolated (except at approved connections to such systems) to prevent galvanic corrosion.
- .2 In particular, contact between dissimilar metals, such as copper and aluminum, in damp or wet locations is not permitted.
- .3 Do not support wiring from pipes, ductwork, etc.

3.15 Mounting Heights

- .1 Mounting height of equipment is from finished floor to centreline of equipment unless specified or indicated otherwise.
- .2 If mounting height of equipment is not specified or indicated, verify before proceeding with installation. Install electrical equipment at following heights unless indicated otherwise.
 - .1 Local switches: 1400 mm.
 - .2 Wall receptacles:
 - .1 General: 300 mm.
 - .2 In mechanical rooms: 1400 mm.
 - .3 In wet or outdoor locations: minimum 1000 mm above finished grade/floor.
 - .3 Panelboards: as required by Code or as indicated.
 - .4 Telephone and LAN outlets:
 - .1 General: 300 mm.

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- .2 Above top of counters or desk: 175 mm.

3.16 Location of Equipment

- .1 Examine and study the Architectural, Structural and Mechanical drawings for items affecting the installation of the Work under this specification and locate conduit runs, pull and junction boxes, disconnects, controlled equipment and panels accordingly and such that working clearances and maximum ceiling heights can be maintained, and to avoid conflict with other installations.
- .2 Any device, panel or equipment which is miss-located as a result of failure to observe the foregoing instructions shall be relocated without extra cost.
- .3 If a specific equipment location is in question, request directions from the Contract Administrator.

3.17 Alignment of Electrical Components

- .1 Where there are two (2) or more equipment items (switches, outlets, panels or related equipment) are installed together, they shall be aligned vertically and/or horizontally to present a neat orderly appearance.
- .2 They shall also be aligned and symmetrical with architectural elements.

3.18 Accessibility

- .1 Install all Work to be readily accessible for adjustment, operation and maintenance.
- .2 Install all devices and protective systems to be accessible as per CEC (latest revision requirements).

3.19 Field Quality Control

- .1 The Contractor shall conduct and pay for tests as identified in part 3.19.6 below.
- .2 Provide a manufacturer's certificate or letter confirming that the entire installation as it pertains to each system had been installed in accordance with the manufacturers' instructions.
- .3 Carry out tests in presence of the Contract Administrator or City Representative.
- .4 Ground fault detectors shall be dynamically tested by injecting current flow into the zero sequence current sensor.
- .5 Submit test results for Contract Administrator's review.
 - .1 Measure phase voltages at loads and adjust transformer taps to within 2% of rated voltage of equipment.
 - .2 Provide upon completion of work, load balance report: phase and neutral currents on panelboards, dry-core transformers and motor control centres, operating under normal load, as well as hour and date on which each load was measured, and voltage at time of test.

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- .6 Conduct following tests:
 - .1 Point to point wire continuity test for all conductors.
 - .2 Power generation and distribution system including phasing, voltage, grounding and load balancing.
 - .3 Lighting and its control.
 - .4 Motors, heaters and associated control equipment including sequenced operation of systems where applicable.
 - .5 Test resistance to ground of the completed grounding electrodes.
 - .6 Insulation resistance testing:
 - .1 Megger circuits, feeders and equipment up to 350 V with a 500 V instrument.
 - .2 Megger 350-600 V circuits, feeders and equipment with a 1000 V instrument.
 - .3 Check resistance to ground before energizing.
- .7 Load Balance:
 - .1 Measure phase current to panelboards with normal loads (lighting) operating at time of acceptance; adjust branch circuit connections as required to obtain best balance of current between phases and record changes.
- .8 Provide instruments, meters, equipment and personnel required to conduct tests during and at conclusion of project.
- .9 Manufacturer's Field Services:
 - .1 Obtain written report from Manufacturer verifying compliance of Work, in handling, installing, applying, protecting and cleaning of product and submit Manufacturer's Field Reports as described in Specification E6..
 - .2 Provide Manufacturer's field services consisting of product use recommendations and periodic site visits for inspection of product installation in accordance with Manufacturer's instructions.
 - .3 Schedule site visits, to review Work, as directed in Section 1.11 - Quality Assurance.
- .10 Submit test results for Contract Administrator's review.

3.20 Construction Period Tests

- .1 All the Work which is required to be placed within the construction or concealed shall be carefully tested and inspected before being permanently covered up.
- .2 All tests shall be made in the presence of the Contract Administrator or the City Representative and shall meet with their approval.

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3.21 Start-Up, Testing and Commissioning

- .1 Upon completion of the installation, the Contractor shall be responsible for testing to determine correct system operation and sequences as intended in the Contract Documents.
- .2 When preliminary checks have been completed and equipment is operating or ready to operate, individual systems shall be setup in accordance with the specifications and/or manufacturer's recommendations. After setup the system shall be placed in operation in conjunction with the Contract Administrator and/or the City's designated operating personnel.
- .3 In general, the start-up and commissioning shall be in accordance with Section 26 05 03 – Commissioning of Electrical Systems.

3.22 Care and Operation

- .1 Instruct the City's representatives in the operation, care and maintenance of equipment.

3.23 Cleaning

- .1 Clean and touch-up surfaces of shop-painted equipment scratched or marred during shipment or installation, to match original paint.
- .2 Clean and prime exposed non-galvanized hangers, racks, and fastenings to prevent rusting.
- .3 In addition to final cleaning in accordance with the Special Conditions and Description of the Work, clean interiors and surfaces of all electrical equipment and general work area periodically to continuously maintain a clean working environment.

3.24 Contractor's Responsibility

- .1 The Contractor shall be responsible for the equipment and work until its completion and final acceptance.
- .2 The Contractor shall replace any item which may be damaged, lost or stolen without additional cost to the City.
- .3 Install all the Work promptly and in advance of concrete pouring or similar construction.
- .4 Co-ordinate with other Divisions the placement of in-slab conduits and sleeves prior to pouring.
- .5 Co-ordinate the Work with other Divisions such that all equipment, conduits and wiring will be installed in the best arrangement.
- .6 Protect finished and unfinished work from damage. Any equipment or material damaged by weather, mishandling or other incident shall be replaced with new equipment and material at the direction of the Contract Administrator and at no additional cost.
- .7 Before acceptance clean all exposed surfaces of lighting luminaries, lamps, Starters, Motor Control Panels and other electrical equipment of dust and plaster. Restore any damaged paint surfaces to factory-quality finish.
- .8 Lighting luminaries' lenses shall be washed and dried before commissioning.

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- .9 Furnish all work and materials in accordance with CSA codes, provincial and local inspection department, and local utility regulatory requirements.

3.25 Substantial Performance Inspection

- .1 Prior to Substantial Performance inspection, submit written confirmation that:
 - .1 The installation as specified is completely assembled and wired.
 - .2 All wiring devices, plates, motor control, lighting fixtures and other equipment are operational, clean and correctly labeled.
 - .3 All systems have been tested as required and are in proper working order.
 - .4 Panel-board directories have been completed and all lamacoid nameplates have been installed.
 - .5 Factory finished equipment has been cleaned, touched-up or refinished to present a new appearance.
 - .6 Switchboards, MCC's, VFD and parameters have been set up and functionally tested.
 - .7 Protection relays and/or instrumentation (circuit breakers, overload relays, ground fault detectors, metering equipment) has been set up and tested as per Coordination Study. Results were provided and approved by the Contract Administrator.
 - .8 Communication Networks, Device Level Busses, have been setup, addressed, tested and are fully functional.
 - .9 Maintenance manuals have been submitted.

END OF SECTION

SCOPE OF ELECTRICAL WORK

1. GENERAL

1.1 Requirements

- .1 Supply and install all material, equipment, wiring, and labour necessary for the installation of the systems detailed on the Contract Documents in accordance with the latest edition of the Canadian Electrical Code (CEC) and in accordance with amendments from the Manitoba Electrical Code (MEC).

1.2 Work Included

- .1 General Requirements:
 - .1 General clean-up.
 - .2 All inspections and obtaining all permits, licenses required by various Inspection Agencies and local regulations related to Electrical Trade.
 - .3 All necessary tools, equipment, and supplies.
 - .4 Shop Drawings.
 - .5 Project Record Documents (As-constructed Drawings).
 - .6 Operating and Maintenance Data, where specified.
- .2 Specific Requirements Included but not Limited to Scope of Work:
 - .1 Electrical equipment including site underground and above ground services and cabling.
- .3 Additional Requirements:
 - .1 Provision of all necessary testing, detailed wiring continuity checks, wiring completion checks, installation integrity checks, functional equipment operation checks and written system verification reports to provide a complete system that is ready for commissioning and start-up (refer also to Division 26 - Commissioning).
 - .2 Provision of commissioning and start-up of all systems included in the Scope of Work.
 - .3 General:
 - .1 Supply, install and connect all luminaires, receptacles and other devices as indicated.
 - .2 Provide all cabling required making a complete and operational facility. Provide raceway systems to allow complete installation for all cables.
 - .3 Provide complete grounding as herein specified and indicated on the Contract Documents. All grounding shall comply with the Canadian Electrical Code and local amendments to this code.

SCOPE OF ELECTRICAL WORK

- .4 Provide electrical wiring, conduit and other appurtenances required to provide power connections as required:
 - .1 From the existing plant distribution panel to the new control panels.
 - .2 From the existing booster station distribution panel to the new control devices.
- .5 Provide power connections from the control panel to the various items of electrical equipment, motors, instrumentation and control equipment.

1.3 Materials

- .1 Bus systems including all forms of buses integral with the electrical power system, together with their associated insulation, supports, bus ducts and protective devices.
- .2 Conductors, including all types of wires, conductors, cables, which form an integral part of the electrical power system.
- .3 Cables and bus support systems which are intended to enclose or support all forms of electrical conductors used for any purpose covered by this scope. This includes cable trays, raceways and all forms of rigid, flexible, metallic and non-metallic conduit, and including conduit for communication systems or others, which may be installed at a later date, or buried conduit for wiring work by others, only when such buried conduit is indicated in the Contract.
- .4 Control panels associated with any electrical equipment covered under this Section of Work unless otherwise noted.
- .5 Modifications to existing electrical equipment.
- .6 Circuit breakers of all types and for all applications associated with electrical equipment, which receives its power supply from the main, auxiliary or emergency (including battery) system.
- .7 Grounding systems, as required by the Canadian Electrical Code, or as otherwise specified in the Contract.
- .8 Control and instrumentation systems - electrical or electronic instrumentation systems, with auxiliary equipment and components, unless specified otherwise.
- .9 Transformers of various types, dry, encapsulated etc., and for all applications.
- .10 Electronic data processing and transmission systems, including auxiliary equipment, interface and components.

1.4 Units of Measure

- .1 The following three (3) conversion methods were used in product and location dimensions:
 - .1 Hard Conversion: industry available products which are manufactured in metric measurements.

SCOPE OF ELECTRICAL WORK

- .2 Soft Conversion: products which are still manufactured in Imperial units and are converted in Specifications using arithmetic conversion factors.
- .3 Rationalized Conversion: dimensions which are soft converted and rounded off for ease of measurements.
- .2 In cases where measurements may be open for interpretation, dual dimensions have been incorporated until hard conversions can be used exclusively.

1.5 Definitions

- .1 All terminologies, abbreviations, and acronyms used in this Document are as listed in the various Standards, Codes, Rules, and Bulletins used herein.
- .2 Where the word *install* is used, unless specifically specified, is also meant to include the supply of the equipment.

1.6 Measurement and Payment

- .1 Scope of Electrical Work:
 - .1 Scope of Electrical Work as described in this Specification will be paid for at the Contract Lump Sum Price for "Electrical" including all items incidental to the Work included in this Specification.

2. PRODUCTS (NOT USED)

3. EXECUTION (NOT USED)

END OF SECTION

STARTING OF ELECTRICAL EQUIPMENT AND SYSTEM

1. GENERAL

1.1 Coordination

- .1 Coordinate starting of electrical equipment and systems with testing, adjusting, and balancing, and demonstration and instruction of:
 - .1 Electrical equipment and systems specified in Division 26.
 - .2 Other equipment and systems specified in other Divisions.
- .2 Where any equipment or system requires testing, adjusting or balancing prior to starting, ensure that such Work has been completed prior to starting of electrical equipment and systems.

2. PRODUCT (NOT USED)

3. EXECUTION

3.1 Energizing Electrical System

- .1 Prior to energizing the new electrical system:
 - .1 Verify supply authority voltage and phase rotation.
 - .2 Close and open all devices to ensure proper mechanical operation.
 - .3 Coordinate with MB Hydro to energize new system as required.
 - .4 Ensure all safety and current limiting devices are installed.

3.2 Starting Motors

- .1 Prior to starting motors:
 - .1 Confirm motor nameplate data with motor starter heater overloads.
 - .2 Confirm motor wiring is connected to correct phases.

3.3 Energizing Equipment

- .1 Prior to energizing equipment provided under other Sections and equipment provided by the Contract Administrator, confirm equipment nameplate with characteristics of power supply.

END OF SECTION

COMMISSIONING OF ELECTRICAL SYSTEMS

1. GENERAL

1.1 Scope of Work

- .1 Testing and commissioning are called for throughout the individual specifications. This does not relieve this trade from providing all testing and commissioning necessary to ensure that systems and equipment operate as required and that they interface with other systems and equipment as required.

1.2 Section Includes

- .1 Commissioning of all building electrical systems and component including:
 - .1 Testing and adjustment.
 - .2 Demonstrations and Instruction.
 - .3 Instructions of all procedures for City's personnel.
 - .4 Updating as-built data.
 - .5 Co-ordination of Operation and Maintenance material.

1.3 Quality Assurance

- .1 Provide qualified trades persons, certified testing agencies, factory trained and approved by the Contract Administrator.
- .2 Submit the names of all personnel to be used during the commissioning activities for City Approval.
- .3 Submit proof of personnel qualification.
- .4 Submit associated permits.

1.4 Commissioning

- .1 The purpose of the commissioning process is to fully test all building systems including architectural, mechanical and electrical components and operating procedures by challenging these systems to realistic operation conditions.
- .2 The commissioning activities shall be co-ordinated by the Contractor.
- .3 Commissioning activities for the electrical systems must have available up to date as-built drawing information and accurate Operations and Maintenance Manuals. These documents shall be a major part of this activity.
- .4 Contractor shall be responsible to update all documentation with information and any changes duly noted during the commissioning exercise.
- .5 Contractor shall arrange for all outside suppliers, equipment manufacturers, test agencies and others as identified in the commissioning sections of this Specification.

COMMISSIONING OF ELECTRICAL SYSTEMS

1.5 Submittals

- .1 A commissioning document shall be prepared by the Contractor prior to conducting these activities for use by the Contract Administrator.
- .2 The electrical Subcontractor shall be responsible for ensuring all activities are properly documented in this manual and co-ordinated through the Contractor.
- .3 As-built drawings and data books must be available two (2) weeks prior to commissioning for review and use by the Contract Administrator prior to the start of the commissioning activities.

1.6 Preparation

- .1 Provide test instruments required for all activities as defined in the commissioning documents.
- .2 Verify all systems are in compliance with the requirements of the commissioning documents prior to the pre-commissioning check out operation.
- .3 Confirm all scheduled activities have identified personnel available.
- .4 Where systems or equipment do not operate as required, make the necessary corrections or modifications, re-test and re-commission.

1.7 System Description

- .1 Perform all start-up operations, control adjustment, trouble shooting, servicing and maintenance of each item of equipment as defined in the commissioning documentation.
- .2 The City will provide list of personnel to receive instructions and will co-ordinate their attendance at agreed upon times.
- .3 Prepare and insert additional data in the operations and maintenance manuals and update as-built drawings when needed as additional data becomes apparent during the commissioning exercise.
- .4 Where instruction is specified in the commissioning manual, instruct personnel in all phases of operation and maintenance using operation and maintenance manuals as the basis of instruction.
- .5 Conduct presentation on the City's premises. The City will provide space.

1.8 Final Report

- .1 This trade shall assemble all testing data and commissioning reports and submit them to the Contract Administrator.
- .2 Each form shall bear signature of recorder, and that of the supervisor of reporting organizer.

COMMISSIONING OF ELECTRICAL SYSTEMS

2. **PRODUCTS (NOT USED)**
3. **EXECUTION (NOT USED)**

END OF SECTION

WIRE AND BOX CONNECTORS 0-1000 V

1. GENERAL

1.1 References

- .1 Canadian Standards Association (CSA), latest adopted edition of:
 - .1 CSA C22.2 No.18.3-12, Conduit, Tubing, and Cable Fittings.
 - .2 CSA C22.2 No.18.4-15, Hardware for the Support of Conduit, Tubing, and Cable.
 - .3 CSA C22.2 No.18.5-13, Positioning Devices.
 - .4 CSA C22.2 No.65-13, Wire Connectors.

2. PRODUCTS

2.1 Materials

- .1 Pressure type wire connectors to: CSA C22.2 No.65, with current carrying parts of copper sized to fit copper conductors as required.
- .2 Fixture type splicing connectors to: CSA C22.2 No.65, with current carrying parts of copper sized to fit copper conductors 10 AWG or less.
- .3 Clamps or connectors for armoured cable, aluminum sheathed cable, mineral insulated cable, flexible conduit, non-metallic sheathed cable as required to: CSA-C22.2 No.18.3, 18.4 and 18.5.

3. EXECUTION

3.1 Installation

- .1 Remove insulation carefully from ends of conductors and:
 - .1 Install mechanical pressure type connectors and tighten screws with appropriate compression tool recommended by Manufacturer. Installation shall meet secureness tests in accordance with CSA C22.2 No.65.
 - .2 Install fixture type connectors and tighten. Replace insulating cap.

END OF SECTION

WIRES AND CABLES 0 - 1000 V

1. GENERAL

1.1 References, Codes, and Standards

- .1 Canadian Standards Association (CSA), latest adopted revisions:
 - .1 CSA C22.2 No. 0.3-09, Test Methods for Electrical Wires and Cables, and Update No. 1.
 - .1 CSA-C22.2 No. 131-14, Type TECK 90 Cable, and Update No. 1.
 - .2 CSA C22.2 No. 38, Thermoset-Insulated Wires and Cables,

1.2 Product Data

- .1 Submit product data in accordance with Division 26.

2. PRODUCTS

2.1 Building Wires

- .1 Conductors: stranded for #10 AWG and larger, minimum power conductor size #12 AWG.
- .2 Copper conductors: size as indicated, with 600 V insulation of chemically cross-linked thermosetting polyethylene (XLPE) material rated RW90.
- .3 All underground wiring in conduit to be RW90 type.
- .4 All direct-buried underground wiring and in wet locations to be TECK90 type.

2.2 Teck Cable

- .1 Conductors:
 - .1 Grounding conductor: copper.
 - .2 Circuit conductors: copper, minimum size #12 AWG or as indicated.
- .2 Outer Jacket:
 - .1 Thermoplastic polyvinyl chloride material with heat, flame, and moisture retardant properties.
 - .2 Flame retardancy of outer jacket to be rated in accordance with CSA C22.2, No. 0.3.
- .3 Armour: interlocking aluminum.
- .4 Inner Jacket: polyvinyl chloride material.
- .5 Insulation:

WIRES AND CABLES 0 - 1000 V

- .3 Type: ethylene propylene rubber.
- .4 Chemically cross-linked thermosetting polyethylene rated type RW90, 1000V.
- .6 Fastenings:
 - .1 One-hole malleable iron straps to secure surface cables 50 mm and smaller. Two-hole steel straps for cables larger than 50 mm.
 - .2 Channel type supports for two (2) or more cables at 1,500 mm centers.
 - .3 Six (6) mm diameter threaded rods to support suspended channels.
- .7 Connectors:
 - .1 Watertight, approved for TECK cable.
 - .5 To reduce corrosion based on dissimilar metals, TECK connectors to be of the same type of metal (if applicable) as to the enclosure it is fastened to.
 - .2 Hazardous Locations:
 - .1 CSA approved and bearing "HL" designation.
 - .2 Watertight type with:
 - .1 an elastomeric bevelled bushing.
 - .2 a funnel entry, splined gland nut.
 - .3 a non-magnetic, stainless steel grounding device with dual grounding action.
 - .4 a taper threaded hub.
 - .5 a hexagonal body and gland nut.
 - .3 Integral seal type with metal-to-metal contact construction.
 - .4 Sealing of multi-conductor cable shall be accomplished with a liquid type polyurethane compound.
 - .5 The fitting must:
 - .1 Provide an environmental seal around the outer jacket of the cable and electrically bond the fitting to the cable armour prior to potting the explosion-proof seal.
 - .2 Allow the possibility of disconnection without disturbing the environmental seal, the electrical bonding or the explosionproof seal.
 - .6 All metal-clad cable fittings, for jacketed and non-jacketed interlocked armour cable, shall incorporate an easily-removable armour stop (not requiring fitting

WIRES AND CABLES 0 - 1000 V

disassembly) ensuring proper positioning of the cable armour during cable termination.

2.3 Control Cables: 600 V Teck 90

- .1 Conductors:
 - .1 Grounding conductor: copper.
 - .2 Circuit conductors: copper, as indicated and minimum #14 AWG otherwise.
- .2 Outer Jacket:
 - .1 Thermoplastic polyvinyl chloride material with heat, flame, and moisture retardant properties.
 - .2 Flame retardancy of outer jacket to be rated in accordance with CSA C22.2, No. 0.3.
- .3 Armour: interlocking aluminum.
- .4 Inner Jacket: polyvinyl chloride material.
- .5 Insulation:
 - .1 Type: ethylene propylene rubber.
 - .2 Chemically cross-linked thermosetting polyethylene rated type RW90, 600V.
- .6 Fastenings:
 - .1 One-hole malleable iron straps to secure surface cables 50 mm and smaller. Two-hole steel straps for cables larger than 50 mm.
 - .2 Channel type supports for two (2) or more cables at 300 mm centers.
 - .3 Six (6) mm minimum diameter threaded rods to support suspended channels.
- .7 Connectors:
 - .1 Watertight, approved for TECK cable.
 - .2 To reduce corrosion based on dissimilar metals, TECK connectors to be of the same type of metal (if applicable) as to the enclosure it is fastened to.
 - .3 Hazardous Locations:
 - .1 CSA approved and bear "HL" designation.
 - .2 Watertight type with:
 - .1 an elastomeric bevelled bushing.

WIRES AND CABLES 0 - 1000 V

- .2 a funnel entry, splined gland nut.
- .3 a non-magnetic, stainless steel grounding device with dual grounding action.
- .4 a taper threaded hub.
- .5 a hexagonal body and gland nut.
- .3 Integral seal type with metal-to-metal contact construction.
- .4 Sealing of multi-conductor cable shall be accomplished with a liquid type polyurethane compound.
- .5 The fitting must:
 - .1 Provide an environmental seal around the outer jacket of the cable and electrically bond the fitting to the cable armour prior to potting the explosion-proof seal.
 - .2 Allow the possibility of disconnection without disturbing the environmental seal, the electrical bonding or the explosionproof seal.
- .6 All metal-clad cable fittings, for jacketed and non-jacketed interlocked armour cable, shall incorporate an easily-removable armour stop (not requiring fitting disassembly) ensuring proper positioning of the cable armour during cable termination.

2.4 Control Cables: Armoured/Unarmoured Control and Instrument Cables (ACIC/CIC)

- .1 Cable: to CAN/CSA-C22.2 No. 239, Control and Instrumentation Cables.
- .2 Conductors:
 - .1 Minimum #18AWG or as noted on the Drawings.
 - .2 Seven (7) strand concentric lay.
 - .3 Class B tinned copper.
 - .4 Twisted pairs/triads.
 - .5 Number of pairs as indicated on drawings.
- .3 Insulation: PVC TW75, 75°C Wet, 105 °C Dry (-40°C), Voltage as noted.
- .4 Inner jacket: XLPE.
- .5 Overall armour: interlocking aluminum armour.
- .6 Overall outer jacket: FT4 flame-retardant rated outer jacket.
- .7 Shielding:

WIRES AND CABLES 0 - 1000 V

- .1 Individual twisted pairs/triads with complete electrical isolation between shields.
- .2 Individual shielded pairs/triads.
- .3 Aluminum/mylar shield with ST drain wire, 100% shield.
- .4 Overall aluminum/mylar shield with ST drain wire.
- .5 Individual drain wires one size smaller than conductor AWG.
- .8 Cable shall be provided with a black, white, colour code and number code for each pair.
- .9 The entire cable assembly to be suitable for pulling in conduit or laying in cable tray.
- .10 Fastenings:
 - .1 One-hole malleable iron straps to secure surface cables 50 mm and smaller. Two-hole steel straps for cables larger than 50 mm.
 - .2 Channel type supports for two (2) or more cables at 300 mm centers.
 - .3 Six (6) mm minimum diameter threaded rods to support suspended channels.
- .11 Connectors:
 - .1 Watertight, approved for TECK cable.
 - .2 To reduce corrosion based on dissimilar metals, TECK connectors to be of the same type of metal (if applicable) as to the enclosure it is fastened to.
 - .3 Hazardous Locations:
 - .1 CSA approved and bearing "HL" designation.
 - .2 Watertight type with:
 - .1 An elastomeric bevelled bushing.
 - .2 A funnel entry, splined gland nut.
 - .3 A non-magnetic, stainless steel grounding device with dual grounding action.
 - .4 A taper threaded hub.
 - .5 A hexagonal body and gland nut.
 - .3 Integral seal type with metal-to-metal contact construction.
 - .4 Sealing of multi-conductor cable shall be accomplished with a liquid type polyurethane compound.
 - .5 The fitting must:

WIRES AND CABLES 0 - 1000 V

- .1 Provide an environmental seal around the outer jacket of the cable and electrically bond the fitting to the cable armour prior to potting the explosion-proof seal.
- .2 Allow the possibility of disconnection without disturbing the environmental seal, the electrical bonding or the explosionproof seal.
- .6 All metal-clad cable fittings, for jacketed and non-jacketed interlocked armour cable, shall incorporate an easily-removable armour stop (not requiring fitting disassembly) ensuring proper positioning of the cable armour during cable termination.

2.5 Single Conductor Cable

- .1 Single conductor wire to be 98% conductivity copper type TEW or TBS insulation rated at 600 V, solid or stranded conductor as required, size as noted on Contract Documents and specified herein, minimum #14 AWG with 90°C.

3. EXECUTION

3.1 General

- .1 Install and rate power cables in accordance with the latest edition of the Canadian Electrical Code requirements.
- .2 Install in accordance with manufacturer's recommendations, observing requirements for minimum bending radius and pulling tensions.
- .2 Minimum power conductor including luminaire drops to be #12 AWG.
- .3 Minimum conductor size #14 AWG for all discrete control cables.
- .4 Minimum conductor size #18 AWG for twisted pair analog signal cables.
- .5 At each end of the run leave sufficient cable length for termination.
- .6 Protect all conductors against moisture during and after installation.
- .7 Protect wiring against damage from welding spatter and other construction activity by suitable means.
- .8 If available blockouts through slabs or walls are insufficient in size or location, enlarge, chip or drill additional openings in accordance with Divisions 3 and 4.
- .9 If available blockouts through slabs or walls are insufficient in size or location, enlarge, chip or drill additional openings and patch.
- .10 Do not use TC cable in areas classified as hazardous locations.
- .11 Arrange wiring in process area such that motor connection boxes and other field mounted devices are entered at the side or bottom of the connection box or enclosure.

WIRES AND CABLES 0 - 1000 V

- .12 Provide sufficient length of "free" cable for motors mounted on slide rails to permit the motor to travel the full length of the rails.
- .13 Install reducing bushings where threaded entry in a motor connection box is larger than the hub size of the cable connector.
- .14 In-line splices are not acceptable unless done in a junction or splice box.
- .15 At the discretion of the Contract Administrator damage to a cable jacket may be repaired in accordance with the manufacturer's recommendation. If requested by Contract Administrator, replace the entire length of a damaged cable.
- .16 Arrange cable supports such that maintenance work or removal of the equipment served by the cable, will not cause any damage to the cable.

1.2 Terminations and Splices

- .1 Wire nuts are permitted only in the following circuits:
 - .1 Lighting circuits.
 - .2 Receptacle circuits.
- .2 Exercise care in stripping insulation from wire. Do not nick conductors.
- .3 Strictly follow manufacturer's instructions with regards to tool size and application methods of terminations and compounds.
- .4 Where screw-type terminals are provided on equipment and instrumentation, terminate field wiring with insulated fork tongue terminals.
- .5 Do not make splices in any of the instrumentation cable runs.
- .6 All instrumentation and control equipment supplied shall be equipped with terminal blocks to accept conductor connections.
- .7 Instrumentation conductors, where terminated at equipment terminals other than clamping type terminal blocks, shall be equipped with self-insulated, locking type terminators, sized as required to fit conductors and screw terminals.

1.3 Re-Use of Existing Wiring

- .1 Except where specifically identified or approved, reuse of existing wiring is not permitted.
- .2 Ensure all existing wiring is tagged prior to disconnection of equipment.
- .3 Tag spare wires to remain as "Spare" and indicate the location of the other end of the wire.

3.2 Installation of Teck Cable 0 - 1000 V

- .1 Install cables.

WIRES AND CABLES 0 - 1000 V

- .2 Group cables wherever possible on channels.
- .3 Lay cable in cable troughs in accordance with Division 26.
- .4 Terminate cables in accordance with Division 26.
- .4 Use TECK cable or wire and conduit in accordance with this Division for power to instruments, for 120 V signals other than those mentioned Digital and Analog signals and as otherwise indicated on the Drawings. Use stranded wire and cable to supply power to instruments.

3.3 Installation of Control Cables

- .1 Install control cables in conduit or cable troughs.
- .2 Ground control cable shield at one end only. Shields to be continuous over entire run.
- .3 Use Twisted Pair Shielded Cables(TPSH) cable for all low level input (24 V and below) and output signals to the control system.
- .4 Provide separation of cables from sources of noise, including other cables.
 - .1 For control signals < 50V, provide separation distances as follows:
 - .1 120 VAC, 8 AWG and smaller: 50 mm.
 - .2 120 VAC, >8 AWG: 300 mm.
 - .3 600 VAC power: 300 mm.
 - .4 VFD or other high harmonic cable: 300 mm in metallic conduit/600 mm other raceway.
 - .5 Medium Voltage: 450 mm.
 - .2 For control signals 120 VAC, provide separation distances as follows:
 - .1 120 VAC, 8 AWG and smaller: none.
 - .2 120 VAC, >8 AWG: metal barrier or 150 mm.
 - .3 600 VAC power: metal barrier or 150 mm.
 - .4 VFD or other high harmonic cable: 150 mm in metallic conduit / 300 mm other raceway.
 - .5 Medium Voltage: 450 mm.
 - .3 Advise the Contract Administrator if these separations cannot be achieved.

WIRES AND CABLES 0 - 1000 V

- .5 Ground shields at one end only. Where possible, ground shields at the end where power is supplied to the cable. Utilize shield grounding bar in panels, where present, to ground overall shields. Individual pair shields to be grounded on appropriate terminals.
- .6 Shield drain wires, at the ungrounded end, are to be taped back to the cable. Do not cut the shield drain wire off.

3.4 Cutting, Patching and Drilling

- .1 Provide all cutting and patching as required.
- .2 Return exposed surfaces to an as-found condition.
- .3 Exercise care where cutting/drilling holes in existing concrete elements so as not to damage existing reinforcing, or any other systems run in the concrete.
 - .1 Locate reinforcing and other existing systems using ground penetrating radar, X-Ray or other suitable means. Mark out on the surface of the concrete the locations of rebar and all other systems.
 - .2 For all holes larger than 50 mm passing through reinforced concrete, mark the location of the desired hole and all embedded systems. Obtain approval from the Contract Administrator prior to cutting.
- .4 Firestop and seal all penetrations.
- .5 Ensure that water ingress will not occur.
- .6 Provide expansion joints for penetrations where shifting can occur.

3.5 Anchor Installation

- .1 The Contractor shall exercise care where installing anchors into existing concrete elements so as not to damage existing reinforcing. All anchors shall be installed utilizing carbide tip drill bits. The existing reinforcing shall be located utilizing a reinforcing bar locator and marked out on the surface of the concrete. The drill holes shall be advanced to the required depth for installation of the anchors. Should reinforcement be encountered while drilling, the hole shall be terminated and repositioned to clear the reinforcement. Do not use core bits that can easily intercept and damage/cut the reinforcing during drilling.

3.6 Workmanship

- .1 Before pulling wire, ensure conduit is dry and clean. If moisture is present, thoroughly dry out conduits; vacuum if necessary. To facilitate pulling, recognized specially manufactured wire pulling lubricants may be used. Do not use grease. Employ suitable techniques to prevent damage to wire when ambient temperature is below the minimum permitted for each insulation type. Do not pull wires into incomplete conduit runs.
- .2 Installation to be free of opens and grounds. Before energization, measure insulation resistance and comply with the Manitoba Electrical Code. Submit data sheet with values measured.

WIRES AND CABLES 0 - 1000 V

- .3 Do not install any power conductor smaller than #12 AWG, except where specifically indicated otherwise, i.e., for fire alarm system station circuits, P.A. wiring, etc.
- .4 Provide conductors as shown on Contract Documents and cable schedule. Minimum conductor sizes are indicated. Voltage drop from lighting panels to farthest outlet must not exceed 2% at full load in any case. Advise Contract Administrator if problem is foreseen.
- .5 Exercise care in stripping insulation from wire. Do not nick conductors.

3.7 Identification, Coding and Balancing

- .1 For branch circuit wiring, follow City of Winnipeg identification standards, and as specified in Division 26.
- .2 Connect single phase equipment to minimize imbalance on feeders. Adjust branch circuiting shown as required for optimum balancing. Record all changes on As-Constructed Drawings.
- .3 Colour code all feeders at all terminations, at all points where taps are made, and at all panel boards, switchboards, motor control centres, etc. Use two wraps of 3M #471 plastic film tape 48 mm wide.
- .4 Conductors sized No. 10 and smaller are required to be factory coloured or numbered, not taped on Site.
- .5 For direct current wiring use red for positive and black for negative.
- .6 Identify each instrumentation conductor with wire numbers using a machine printed heat shrink wire marker.
- .7 Install cable tags at control panel end of cable.

3.8 Testing

- .1 All power and control wiring shall be tested for insulation resistance value with a megger. Resistance values shall be as recommended by the cable manufacturer.
- .2 Test all conductors for opens, shorts, or grounds.
- .3 All wire test results shall be properly tabulated, signed, dated, and submitted to the Contract Administrator.

END OF SECTION

GROUNDING

1. GENERAL

1.1 Description

- .1 Supply and install a complete grounding system to include new equipment provided in this Contract. Securely and adequately ground all components of the electrical system in accordance with the requirements of all related sections in the latest Canadian Electrical Code, Local Building Code, and the local Electrical Inspection Branch.
- .2 The system is to consist of cables, supports, and all necessary materials and inter-connections to provide a complete system. Measured resistance to ground of the network shall not exceed 5 ohms.

1.2 References

- .1 American National Standard Institute (ANSI)/Institute of Electrical and Electronics Engineers (IEEE):
 - .1 ANSI/IEEE 837, Standard for Qualifying Permanent Connections Used in Substation Grounding.
 - .2 IEEE 80 (2013), IEEE Guide for Safety in AC Substation Grounding.
- .2 Canadian Standards Association (CSA):
 - .1 CSA C22.1-18, Canadian Electrical Code, Part 1, Safety Standard for Electrical Installations, and Update No. 1 (2018).

2. PRODUCTS

2.1 Equipment

- .1 Rod electrodes:
 - .1 Copper clad steel, 19 mm dia by 3 m long. Provide longer ground rods as indicated on the Drawings. Where multiple rods are connected, utilize a threadless compression coupling.
 - .2 Acceptable Manufacturers:
 - .1 Burndy 38-7408-02.
 - .2 Slacan 9340.
 - .3 Joslyn J5349.
 - .4 Hydrel 3410G.
 - .5 T & B GR7510.

GROUNDING

- .2 Cables #2/0 and smaller to be connected to ground bars via Type QA-2B. Connections for cables larger than #3/0 shall be brazed.
- .3 Conductors:
 - .1 All insulated ground wires to be stranded copper TWH complete with a green jacket unless otherwise shown.
 - .2 PVC insulated coloured green, stranded soft annealed copper wire No. 10 AWG for grounding meter and relay cases.
 - .3 Uninsulated ground wires shall be bare stranded copper, soft annealed, CSA FT1 for outdoors. Size as indicated.
- .4 Non-corroding accessories necessary for grounding system, type, size, material as indicated, including but not necessarily limited to:
 - .1 Grounding and bonding bushings.
 - .2 Protective type clamps.
 - .3 Bolted type conductor connectors.
 - .4 Thermit welded type conductor connectors.
 - .5 Bonding jumpers, straps.
 - .6 Pressure wire connectors.
 - .7 Wire connectors and terminations: as indicated.
 - .8 Acceptable Manufacturers:
 - .1 Erico.
 - .2 Burndy.
 - .3 Or approved equal.
- .5 Compression Connection – “C” Tap
 - .1 Requirements:
 - .1 Material: solid copper.
 - .2 Type: “C” Tap.
 - .2 Acceptable Manufacturer and Model:
 - .1 Burndy YGHC.
 - .2 Or approved equal.

GROUNDING

- .6 Compression Connection – Butt Splice:
 - .1 Requirements:
 - .1 Material: solid copper.
 - .2 Type: heavy duty splice.
 - .2 Acceptable Manufacturer and Model:
 - .1 Burndy YGHS.
 - .2 Or approved equal in accordance with B7.
- .7 Exothermic Connection:
 - .1 Required material: copper.
 - .2 Acceptable Manufacturer and Model:
 - .1 Burndy ThermOweld or BurndyWeld product lines.
 - .2 Or approved equal.

3. EXECUTION

3.1 GENERAL

- .1 Install complete permanent, continuous grounding system, including conductors, accessories.
- .2 All connectors shall be installed in accordance with Manufacturers' requirements.
- .3 Protect exposed grounding conductors from mechanical injury.
- .4 Make buried connections and connections to electrodes, using copper welding by thermit process to ANSI/IEEE 837.
- .5 Soldered joints shall not be permitted.
- .6 All frames and metallic enclosures of all electrical equipment and electrically operated equipment shall be grounded via a ground wire.
- .7 All transformers, switchgear, MCCs, panel boards and splitters fed from the main distribution centre shall be grounded by grounding conductors sized as shown. The ground wire shall be terminated at each end with an appropriate grounding lug which shall be connected to the equipment ground bus. Ground wire to be green TWH.
- .8 Use mechanical connectors for grounding connections to equipment provided with lugs.

GROUNDING

- .9 All sub panels such as lighting panels, local distribution panels, etc., shall be grounded with a green ground wire run back to the panel from which it is fed. The ground conductor shall be sized according to the Canadian Electrical Code.
- .10 All main distribution centres, MCCs, switchgear, and all panels requiring equipment grounds shall contain a ground bus of adequate size, and tapped for lugs for the ground wire required.
- .11 All bolted connections must be accessible.
- .12 All motors shall be grounded by means of an adequately sized green ground wire contained within the feeder conduit.
- .13 Include a separate green ground wire in all power conduits including branch circuit wiring sized to Canadian Electrical Code.
- .14 Expansion joints and telescoping sections of raceways shall be bonded using jumper cables as per Canadian Electrical Code.
- .15 Use compression connectors for all grounding splices and terminations unless otherwise shown on the Contract Documents.
- .16 Install rigid conduit sleeves where ground wires pass through concrete slabs.
- .17 Conduit installed buried in earth or installed in or under grade floor slabs shall have separate ground wire installed.
- .18 Bond single conductor, metallic armoured cables to cabinet at supply end, and provide non-metallic entry plate at load end.
- .19 Exterior run grounding conductors shall be run in rigid PVC conduit where required for support or mechanical protection.
- .20 Minimum bending radius for grounding conductors shall be 2 inches.
- .21 Install conductors with a minimum of bends and without kinking. Where bends are unavoidable, make bends as smoothly as possible.

3.2 Electrode Installation

- .1 Make special provision for installing electrodes that will give acceptable resistance to ground value, where rock or sand terrain prevails.
- .2 Install rod electrodes and make grounding connections as shown on the Drawings.
- .3 Connect multiple rod electrodes together as shown on the Drawings.
- .4 Locate all existing underground services in the area prior to installation of ground electrodes. Ensure no existing underground pipes or cables are damaged during the installation of the electrodes.

GROUNDING

3.3 System and Circuit Grounding

- .1 Install system and circuit grounding connections to neutral of secondary 600 V system, secondary 208 V system.

3.4 Equipment Grounding

- .1 Install grounding connections to typical equipment included in, but not necessarily limited to following list: Service equipment, transformers, switchgear, duct systems, frames of motors, MCCs, starters, control panels distribution panels.

3.5 Field Quality Control

- .1 Perform tests in accordance with Division 26.
- .2 Perform ground continuity and resistance tests using method appropriate to Site conditions and to approval of Contract Administrator and local Authority Having Jurisdiction over installation. Perform ground resistance test before backfill.
- .3 Perform tests before energizing electrical system.
- .4 Disconnect ground fault indicator during tests.

END OF SECTION

HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

1. GENERAL

1.1 Work Included

- .1 Supply and install all hangers, supports and inserts for the installation shown on the Contract Documents and specified herein, as necessary to fasten electrical equipment securely to the building structure.

2. PRODUCT

2.1 Framing and Support System

- .1 Materials:
 - .1 Intermediate duty supporting structures shall employ 41 mm square strut channel together with the Manufacturer's connecting components and fasteners for a complete system.
 - .2 Heavy duty supporting structures to be fabricated and welded from steel structural members and prime painted before installation.
 - .3 Shall be rated for use in hazardous locations and category environments as necessary.
- .2 Finishes:
 - .1 Hot dipped galvanized.
 - .2 Nuts, bolts, machine screws: cadmium plated.
- .3 Square strut channel:
 - .1 Section 41 mm square strut channel or as required for load and span, with mounting screws, or approved. 41 mm square strut channel is a minimum standard for supporting conduits 50 mm and larger.

2.2 Concrete and Masonry Anchors

- .1 Materials: hardened steel inserts, zinc plated for corrosion resistance. All anchor bolts must be galvanized.
- .2 Components: non-drilling anchors for use in predrilled holes, sized to safely support the applied load with a minimum safety factor of four (4).

2.3 Non-Metallic Anchors

- .1 Material: plastic anchors for sheet metal screws.

2.4 Cable Supports and Clamps

- .1 General: as per conduit supports, except that for single conductor cables, suitable non-ferrous, or approved stainless steel or aluminum clamps shall be used.

HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

3. EXECUTION

3.1 General

- .1 Do not cut or drill beams, joists or structural steel unless written permission of the Contract Administrator is obtained.
- .2 Distance between conduit or cable supports not to exceed code requirements.
- .3 Supports to be suitable for the real loads imposed by equipment.
- .4 Supports to be securely fastened, free from vibration and excessive deflection or rotation. Maximum deflections are 4 mm over a 1 m span and 8 mm over a 2 m span.
- .5 Install fastenings and supports as required for each type of equipment cables and conduits, and in accordance with manufacturer's installation recommendations.
- .6 Provide rack with 25% spare capacity for multiple runs.
- .7 Provide channel support with fittings for vertical runs of conduit and cables.

3.2 Installation

- .1 Secure equipment to solid masonry, tile and plaster surfaces with lead anchors or nylon shields.
- .2 Secure equipment to poured concrete with expandable inserts.
- .3 Secure equipment to hollow masonry walls or suspended ceilings with toggle bolts.
- .4 Support equipment, conduit or cables using clips, spring loaded bolts, cable clamps designed as accessories to basic channel members.
- .5 Fasten exposed conduit or cables to building construction or support system using straps.
 - .1 One-hole malleable iron or steel straps to secure surface conduits and cables 50 mm and smaller.
 - .2 Two-hole steel straps for conduits and cables larger than 50 mm.
 - .3 Beam clamps to secure conduit to exposed steel Work.
- .6 Suspended support systems.
 - .1 Support individual cable or conduit runs with 6 mm diameter threaded rods and spring clips.
 - .2 Support two (2) or more cables or conduits on channels supported by 6 mm diameter threaded rod hangers where direct fastening to building construction is impractical.
- .7 Use plastic anchors for light loads only. Use metal anchors for all other loads.
- .8 Shot driven pins may only be used with written approval of the Contract Administrator.

HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

- .9 Use round or pan head screws for fastening straps, boxes, etc.
- .10 Support outlet boxes, junction boxes, panel tubs, etc., independent of conduits running to them. Support conduits within 600 mm of outlet boxes. Support surface mounted panel tubs with a minimum of four (4) 6 mm fasteners.
- .11 Provide metal brackets, frames, hangers, clamps and related types of support structures where indicated or as required to support conduit and cable runs.
- .12 Ensure adequate support for raceways and cables dropped vertically to equipment where there is no wall support.
- .13 For surface mounting of two or more conduits, refer to Section 26 05 34 – Conduits, Conduit Fastenings and Fittings.
- .14 Ensure adequate support for raceways and cables dropped vertically to equipment where there is no wall support.
- .15 Do not use wire lashing or perforated strap to support or secure raceways or cables.
- .16 Do not use supports or equipment installed for other trades for conduit or cable support except with permission of other trade and approval of the Contract Administrator.

END OF SECTION

SPLITTERS, JUNCTION BOXES, PULL BOXES AND CABINETS

1. GENERAL

1.1 References

- .1 National Electrical Manufacturers Association (NEMA):
 - .1 NEMA ICS 6, Industrial Control and Systems: Enclosures.

1.2 Shop Drawings and Product Data

- .1 Submit Shop Drawings and product data for cabinets in accordance with Section 26 05 00.
- .2 Provide Manufacturer's printed product literature, specifications and datasheet and include product characteristics, performance criteria, physical size, finish and limitations.

2. PRODUCTS

2.1 Junction Boxes, Cabinets, and Pull Boxes

- .1 NEMA Type of enclosure refer to Division 26.
 - .1 All installations in hazardous areas shall be NEMA4X.
 - .2 All installations in outdoor or wet locations shall be NEMA4x.
- .2 Materials:
 - .1 Code gauge sheet steel, welded construction, phosphatized and factory paint finish.
 - .2 Components:
 - .1 For flush mounting, covers to overlap box by 25 mm minimum all around with flush head cover retaining screws.
 - .2 Use rolled edges for surface boxes.
 - .3 Junction boxes mounted in exterior walls shall be complete with box vapour barriers.

2.2 Cabinets

- .1 Materials:
 - .1 Locks: to match panelboards.
- .2 Components:
 - .1 With hinged door and return flange overlapping sides, with handle, lock and catch for surface mounting, size as indicated or to suit.
 - .2 Install a back mounting plate for DIN rail mounted terminal blocks. Plate to be painted white enamel.

SPLITTERS, JUNCTION BOXES, PULL BOXES AND CABINETS

- .3 Install metal divider in cabinets with more than one voltage.
- .4 Surface or flush with trim and hinged door, latch and lock and two (2) keys, size as indicated or to suit. Keyed to match panel board keys 19 mm.

3. EXECUTION

3.1 Installation

- .1 Junction Boxes and Pull Boxes:
 - .1 Supply all pull boxes and junction boxes shown on the Contract Documents or required for the installation.
 - .2 Boxes installed in party walls to be offset by a minimum of one (1) stud space.
 - .3 Install in inconspicuous but accessible locations, above removable ceilings or in electrical rooms, utility rooms or storage areas.
 - .4 Identify with system name and circuit designation as applicable.
 - .5 Size in accordance with the Canadian Electrical Code, as a minimum.
 - .6 Terminate cables and conductors as required.
 - .7 Make all necessary cable entry holes in junction boxes supplied by Contractor or others, regardless of material.
- .2 Cabinets:
 - .1 Mount cabinets with top not greater than 1980 mm above finished floor, coordinated with masonry, panelboards, fire hose cabinets and similar items.
 - .2 Install terminal block where indicated.
- .3 Identification:
 - .1 Provide equipment identification in accordance with Division 26.
 - .2 Install identification labels indicating system name, voltage, and phase.

END OF SECTION

OUTLET BOXES, CONDUIT BOXES AND FITTINGS

1. GENERAL

1.1 Work Included

- .1 Provide a complete system of boxes for the installation of wiring and equipment.

1.2 References

- .1 Canadian Standards Association (CSA):
 - .1 CSA C22.1-Canadian Electrical Code, Part 1.

2. PRODUCTS

2.1 Outlet and Conduit Boxes General

- .1 Size boxes in accordance with CSA C22.1.
- .2 102 mm square or larger outlet boxes as required for special devices.
- .3 Gang boxes where wiring devices are grouped.
- .4 Blank cover plates for boxes without wiring devices.
- .5 Combination boxes with barriers where outlets for more than one system are grouped.

2.2 Outlet Boxes for Metal Conduit

- .1 Materials:
 - .1 Surface mounting exposed: cast ferrous for threaded conduit, with attached lugs, two (2) coats corrosion resistant finish.
- .2 Components:
 - .1 Ceiling outlets, surface mounting:
 - .1 Cast outlet boxes suitable for rigid conduit.
 - .2 Manufacturer: Crouse-Hinds VXF/VFT series or approved equal.
 - .2 Wall outlets, surface, exposed mounting or used for outdoor outlets:
 - .1 One or more gang.
 - .2 Manufacturer: Crouse-Hinds FS series or FD series, Condulet, or approved equal.
 - .3 Covers: unless wiring devices and plates are mounted, provide blank, round canopy covers to match boxes.

OUTLET BOXES, CONDUIT BOXES AND FITTINGS

2.3 Conduit Boxes

- .1 Cast FS or FD Feraloy boxes with factory-threaded hubs and mounting feet for surface wiring of switches and receptacle.

2.4 Fittings - General

- .1 Bushing and connectors with nylon insulated throats.
- .2 Knock-out fillers to prevent entry of debris.
- .3 Conduit outlet bodies for conduit up to 32 mm and pull boxes for larger conduits.
- .4 Double locknuts and insulated bushings on sheet metal boxes.

2.5 Cable Transit Boxes and Seals

- .1 Multidiameter sealing modules.
- .2 Wedge kit and stay plate to ensure adequate seal (gas transit, firestopping, etc.) as per manufacturer's instructions.
- .3 Transit frame suitable for bolting to transition surface.
- .4 Manufacturer approved lubricant for suitable for cable and module installation.

3. EXECUTION

3.1 Installation

- .1 NEMA Type of boxes refer to Division 26.
- .2 Support boxes independently of connecting conduits.
- .3 Fill boxes with paper, sponges or foam or similar approved material to prevent entry of debris during construction. Remove upon completion of Work.
- .4 Provide correct size of openings in boxes for conduit, mineral insulated and armoured cable connections. Reducing washers are not allowed.
- .5 Install all outlets flush and surface mounted as required for the installation.
- .6 Surface mount above suspended ceilings, or in unfinished areas.
- .7 Adjust position of outlets in finished masonry walls to suit course lines. Coordinate cutting of masonry walls to achieve neat openings for all boxes.
- .8 Do not distort boxes during installation. If boxes are distorted, replace with new boxes.
- .9 Use plaster rings to correct depth. Use 30 mm on concrete block.
- .10 Do not use sectional boxes.

OUTLET BOXES, CONDUIT BOXES AND FITTINGS

- .11 Provide boxes sized as required by the Canadian Electrical Code.
- .12 Install vapour barrier material to surround and seal all outlet boxes located on exterior walls of building. Maintain wall insulation.
- .13 Outlets installed in partition walls to be offset by a minimum of one stud space.
- .14 Primary bushings in termination box for cable connection.
- .15 Secondary bushings in termination box for bus duct connection.

END OF SECTION

CONDUITS, CONDUIT FASTENINGS AND CONDUIT FITTINGS

1. GENERAL

1.1 References

- .1 Canadian Standards Association (CSA):
 - .1 CSA C22.2 No. 18.1 Metallic Outlet Boxes.
 - .2 CSA C22.2 No. 18.2 Non-metallic Outlet Boxes.
 - .3 CSA C22.2 No. 18.3 Conduit, Tubing, and Cable Fittings.
 - .4 CSA C22.2 No. 18.4 Hardware for the Support of Conduit, Tubing, and Cable.
 - .5 CSA C22.2 No. 18.5 Positioning Devices.
 - .6 CSA C22.2 No. 45.1 Electrical Rigid Metal Conduit – Steel.
 - .7 CSA C22.2 No. 45.2 Electrical Rigid Metal Conduit — Aluminum, Red Brass, and Stainless Steel.
 - .8 CSA C22.2 No. 56, Flexible Metal Conduit and Liquid-Tight Flexible Metal Conduit.
 - .9 CSA C22.2 No. 83, Electrical Metallic Tubing.
 - .10 CSA C22.2 No. 227.3, Non-metallic Mechanical Protection Tubing (NMPT).

2. PRODUCTS

2.1 Conduits

- .1 Rigid metal conduit: to CSA C22.2 No. 45.2, aluminum threaded.
- .2 Epoxy coated conduit: to CSA C22.2 No. 45.1, with zinc coating and corrosion resistant epoxy finish inside and outside.
 - .1 Coated with Columbex Green-Guard inside and outside. All joints and conduit scratches shall be repaired with Green-Guard surface cleaner, primer, and touch-up compound.
- .3 Flexible metal conduit: to CSA C22.2 No. 56, aluminum liquid-tight flexible metal.
- .4 Rigid PVC conduit: to CSA C22.2 No. 211.2.

2.2 Conduit Fastenings

- .1 One (1) hole stainless steel straps to secure surface conduits 50 mm and smaller.
- .2 Two (2) hole stainless steel straps for conduits larger than 50 mm.
- .3 Beam clamps to secure conduits to exposed steel work.
- .4 Channel type supports for two or more conduits at 1 m on centre.

CONDUITS, CONDUIT FASTENINGS AND CONDUIT FITTINGS

- .5 Threaded stainless steel rods, 9 mm diameter, to support suspended channels.

2.3 Conduit Fittings

- .1 Fittings: to CSA C22.2 No. 18.3, No. 18.4, and No. 18.5, manufactured for use with conduit specified. Coating: same as conduit.
- .2 Ensure factory "ells" where 90 degrees bends for 25 mm and larger conduits.

2.4 Fish Cord

- .1 Polypropylene.

3. EXECUTION

3.1 Installation

- .1 Install all conduit, conduit fittings and accessories in accordance with the latest edition of the CEC in a manner that does not alter, change, or violate any part of the installed system components or the CSA/cUL certification of these components.
- .2 Install conduits to conserve headroom in exposed locations and cause minimum interference in spaces through which they pass.
- .3 Conceal conduits except in mechanical and electrical service rooms and in unfinished areas.
- .4 Use epoxy coated conduit underground, in concrete, and in Category 2 locations.
- .5 Install conduit sealing fittings in hazardous areas. Fill with compound rated for the application and to manufacturer's instructions.
- .6 Use liquid tight flexible metal conduit for connection to motors or vibrating equipment.
- .7 Use explosion proof flexible connection for connection to explosion proof motors.
- .8 Minimum conduit size for lighting and power circuits: 19 mm.
- .9 Bend conduit cold. Replace conduit if kinked or flattened more than 1/10th of its original diameter. Use bending equipment specifically intended for the purpose.
- .10 Mechanically bend steel conduit over 19 mm in diameter.
- .11 Field threads on rigid conduit must be of sufficient length to draw conduits up tight.
- .12 Install fish cord in empty conduits.
- .13 Remove and replace blocked conduit sections.
 - .1 Do not use liquids to clean out conduits.
- .14 Dry conduits out before installing wire.

CONDUITS, CONDUIT FASTENINGS AND CONDUIT FITTINGS

- .15 Connect conduit to equipment securely to maintain continuity for the purpose of bonding to ground.
- .16 Provide for the expansion and contraction of the conduit system.

3.2 Surface Conduits

- .1 Run parallel or perpendicular to building lines.
- .2 Locate conduits behind infrared or gas fired heaters with 1.5 m clearance.
- .3 Run conduits in flanged portion of structural steel.
- .4 Group conduits wherever possible on suspended or surface mounted aluminum channels.
- .5 Do not pass conduits through structural members except as indicated. Do not locate conduits less than 75 mm parallel to steam or hot water lines with minimum of 25 mm at crossovers.

3.3 Concealed Conduits

- .1 Run parallel or perpendicular to building lines.
- .2 Do not install conduits in terrazzo or concrete toppings.

3.4 Conduits in Cast-In-Place Concrete

- .1 Use epoxy coated rigid steel conduits.
- .2 Locate to suit reinforcing steel.
 - .1 Install in centre one third of slab.
- .3 Protect conduits from damage where they stub out of concrete.
- .4 Install sleeves where conduits pass through slab or wall.
- .5 Provide oversized sleeve for conduits passing through waterproof membrane, before membrane is installed.
 - .1 Use cold mastic between sleeve and conduit.
- .6 Conduits in slabs: minimum slab thickness 4 times conduit diameter.
- .7 Encase conduits completely in concrete with minimum 25 mm concrete cover.
- .8 Organize conduits in slab to minimize cross-overs.

3.5 Conduits in Cast-In-Place Slabs on Grade

- .1 Use epoxy coated rigid steel conduits.
- .2 Run conduits 25 mm and larger below slab and encase in 75 mm concrete envelope.

CONDUITS, CONDUIT FASTENINGS AND CONDUIT FITTINGS

- .1 Provide 50 mm of sand over concrete envelope below floor slab.

3.6 Conduits Underground

- .1 Slope conduits to provide drainage.
- .2 Waterproof joints (PVC accepted) with heavy coat of bituminous paint.

3.7 Cleaning

- .1 On Completion and verification of performance of installation, remove surplus materials, excess materials, rubbish, tools, and equipment.

END OF SECTION

PROCESS MOTORS LESS THAN 150 KW

1. GENERAL

1.1 Description

- .1 This Section specifies the motors for the submersible pumps.
- .2 Low voltage electric motors and accessories, furnished under other Sections, and which are a part of equipment assemblies shall be in conformance with the requirements specified in this Section, unless otherwise noted. This Section includes performance, and descriptive type specifications.
- .3 Unless otherwise specified or approved, all electric motors furnished and installed by the Contractor shall conform to the requirements specified herein.
 - .1 Motors connected to variable frequency drives shall be inverter-duty rated in accordance with the requirements of NEMA MG 1.
 - .2 Motors rated 0.75 kW or greater shall be premium-efficiency-type per NEMA MG.

1.2 Reference Documents

- .1 Conform to the following reference standards or their equivalents, latest adopted revision:
 - .1 Institute of Electrical and Electronics Engineers (IEEE):
 - .1 112: Standard Test Procedure for Polyphase Induction Motors and Generators.
 - .2 114: Single Phase Induction Motors – Testing.
 - .3 1349: Guide for the Application of Electric Motors in Class I, Division 2 and Class I, Zone 2 Hazardous (Classified) Locations.
 - .2 National Electric Manufacturers Association (NEMA):
 - .1 MG 1 : Motors and Generators.
 - .3 Canadian Standards Association (CSA):
 - .1 CSA C22.1, Canadian Electrical Code, Part 1, Safety Standard for Electrical Installations.
 - .1 Manitoba Electrical Code.
 - .2 CSA C22.2 No. 145, Motors and Generators for Use in Hazardous (Classified) Locations.
 - .3 CSA C390, Test Methods, Marking Requirements and Energy Efficiency Levels for Three-phase Induction Motors.

PROCESS MOTORS LESS THAN 150 KW

1.3 Submittals

- .1 Shop Drawings: Submit with the related items of equipment in accordance with Specification E6 and Section 26 05 00. In addition, submit the following details: Provide the specified information for each typical size or type of motor driven equipment.
 - .1 Shop Drawings and product data to include:
 - .2 Shop Drawings and product data in accordance with Division 26.
 - .1 Complete list of all motors to be furnished.
 - .2 Overall dimensions of motor.
 - .3 Outlines, dimensions, weights, and wiring diagrams.
 - .4 Arrangement and dimensions of accessories.
 - .5 Shaft centreline to base dimension.
 - .6 Shaft extension diameter and keyway, coupling dimensions and details.
 - .7 Fixing support dimensions.
 - .8 Location of main and accessories boxes with size of conduit entrance.
 - .9 Terminal box location and size of terminals. Efficiency and power factor at 1/2, 3/4 and full load.
 - .10 Bearing design data, grease requirements and part numbers.
 - .11 Nameplate data.
 - .12 Shop test report.
 - .13 Field acceptance test report.
 - .14 Built in overload protection device.
 - .15 Diagram of connections.
 - .16 Speed/torque characteristic.
 - .17 Installation data.
 - .18 Rotation direction.
 - .19 Starting restrictions (time between starts).
 - .20 Terminal leads marking.
 - .21 Bearing data (including part numbers).

PROCESS MOTORS LESS THAN 150 KW

- .22 Recommended lubricant.
 - .23 Design ambient temperature.
 - .24 RTD parameters and quantity.
 - .25 The ABMA L-10 rated life for the motor bearings.
 - .26 The nominal efficiency for all motors.
 - .27 Class, division, group and UL frame temperature limit code for explosion-proof motors.
- .3 Submit Pump, Motor and VFD, if applicable, Coordination Certificate.

1.4 Service Conditions

- .1 Unless specified otherwise, provide motors suitable for continuous operation at an elevation of 237 m above sea level.
- .2 Provide motors suitable for continuous operation in a 40°C ambient temperature.

1.5 Quality Assurance

- .1 Provide as in accordance with Section 26 05 00 – Common Work Results for Electrical.
- .2 Build motors in accordance with CSA C22.2 No. 145, NEMA Standard MG1, and to the requirements specified.
- .3 Motors to comply with the latest reference standards listed below.
 - .1 Canadian Electrical Code (CEC).
 - .2 Underwriters Laboratories of Canada (ULC).
 - .3 National Electric Manufacturers Association (NEMA).
 - .1 NEMA Standard MG 1 - Motors and Generators.
 - .4 American Bearing Manufacturers Association (ABMA).
 - .5 American National Standard Institute (ANSI).
 - .6 Institute of Electrical and Electronics Engineers (IEEE).
 - .1 IEEE Standard 112 – Standard Test Procedure for Polyphase Induction Motors and Generators.
 - .2 IEEE 1349 - Guide for the Application of Electric Motors in Class I, Division 2 and Class I, Zone 2 Hazardous (Classified) Locations.

PROCESS MOTORS LESS THAN 150 KW

- .4 Routine tests shall be performed on representative motors, and shall include the information described on NEMA MG 1-12.61. Efficiency shall be determined in accordance with IEEE Publication No. 112, Method B. Power factor shall be measured on representative motors.

1.6 Delivery, Storage and Handling

- .1 Ship, protect and store equipment in a manner that prevents damage or premature aging.
- .2 Handle motors with suitable lifting equipment.
- .3 Shipping:
 - .1 Ship motors assembled to driven equipment complete except where partial disassembly is required by transportation regulations or for protection of components.
 - .2 Pack spare parts in containers bearing labels clearly designating contents and pieces of equipment for which intended.
 - .3 Deliver spare parts at same time as associated devices. Deliver to the City after completion of Work.
- .4 Receiving and Storage:
 - .1 Inspect and inventory items upon delivery to Site.
 - .2 Store and safeguard equipment and material in heated, dry, weather-protected storage facility as recommended by equipment manufacturer..
 - .3 Protect motors from moisture at all times.

2. PRODUCTS

2.1 Acceptable Manufacturers

- .1 U.S. Motors.
- .2 Baldor.
- .3 General Electric.
- .4 GEC Alsthom.
- .5 Reliance.
- .6 Siemens.
- .7 Toshiba.
- .8 Westinghouse.

PROCESS MOTORS LESS THAN 150 KW

2.2 Materials

- .1 NEMA MG-1.
- .2 Lead markings: to NEMA.
- .3 Unless specified otherwise, provide all motors with:
 - .1 Cast iron frame.
 - .2 Cast metal fan blades and shrouds.
 - .3 Stainless steel hardware.
 - .4 Non-hygroscopic windings.

2.3 Components

- .1 Bearings:
 - .1 Provide sealed ball bearing type on motors less than 37.5 KW.
- .2 Provide adequately sized, diagonally split, gasketed NEMA 7 terminal boxes complete with threaded hub for conduit entry for explosion-proof motors.
- .3 Provide a ground connection and lifting eyes or lugs.
- .4 Motors are to be aligned and balanced with the related equipment in the shop to minimize vibration and undue stresses.
- .5 Current Imbalance:
 - .1 Do not exceed the values tabulated below when the motor is operating at any load within its service factor rating and is supplied by a balanced voltage system:
 - .1 Under 37.5 kW: 25%
 - .2 Base imbalance criteria upon the lowest value measured.

2.4 High Efficiency Motors

- .1 High efficiency vertical motors efficiency to be within 0.5% of values stated for horizontal motors.
- .2 Test motor efficiency in accordance with CSA C390, or equivalent, which accounts for stray load losses and measures them indirectly based on the IEEE method.

PROCESS MOTORS LESS THAN 150 KW

2.5 Motors to 150 kW

.1 General:

- .1 Unless otherwise specified, motor to be 3 phase, squirrel cage, full voltage start, high efficiency induction type.
- .2 Provide positive temperature co-efficient thermistor for all motors over 25 kW. One (1) thermistor should be provided for each phase, factory embedded into the motor windings.
- .3 The thermistor shall be compatible with the thermistor protection relays provided by others.

.2 Rating:

- .1 Rated for 600/3/60 VAC service unless otherwise specified.
- .2 Motors less than 0.5 hp or less to be 120 V, 60 Hz, single phase service, and all motors greater than 0.75 hp and smaller than 1.5HP to be 208 V, 60 Hz, three phase service. Refer to drawings and specifications for exact ratings.
- .3 Design motors for full voltage starting, capable of running successfully when terminal voltage is from +10% to -10% of nameplate voltage.
- .4 Provide all motors which run continuously for heavy duty service, rated high efficiency, and TEFC unless otherwise specified.
- .5 Squirrel cage induction type, with a service factor of 1.15 at 40°C ambient, Class F insulation and non-hygroscopic windings unless otherwise specified.
- .6 Provide motors with NEMA Design B torque characteristics. Size motors to satisfy the driven equipment's starting torque requirements. For special high torque applications such as sweep arm drives, motors with Design C characteristics may be specified or provided subject to the Contract Administrator approval.
- .7 Motors with a service factor of 1.0 to operate at no more than 90% of their nameplate current rating and motors with a service factor of 1.15 to operate at not more than 100% of their nameplate current rating.
- .8 Motors shall have the capacity sufficient to operate the driven load and associated devices under all conditions of operation without overloading. They shall not be smaller than the kW rating shown on the equipment specification sheets.

.3 Equipment electrical motor requirements classification:

- .1 Type 1 (General Duty): Unless specified otherwise on data sheet, TEFC enclosures, to NEMA MG1. If VFD driven meet requirements of NEMA MG1, Part 30 and Part 31.
- .2 Type 2 (Process): Unless specified otherwise on data sheet, TEFC enclosures, to NEMA MG1, suitable for moist and corrosive environment. All internal surfaces to be coated with an epoxy paint.

PROCESS MOTORS LESS THAN 150 KW

- .3 Type 3 (Explosion-proof type): Motors to be rated for operation in a Class 1, Division 1, Groups C and D or Zone 1 Groups IIA and IIB hazardous location in accordance with CSA C22.1. Provide an approved breather/drain device to be provided in the motor drain hole.
- .4 Type 4 (submersible applications): Motors to be TEXP, waterproof with 316SS motor shaft, rated for submerged operation.
 - .1 Submersible motors installed in hazardous locations shall also conform to the requirements of Type 3.
- .4 Enclosure and Insulation:
 - .1 Enclosures and insulation systems are specified within this Section. Temperature rise for all motor types not to exceed that permitted by Note II, paragraph 12.42, NEMA MG1.
 - .2 Insulation to be non-hygroscopic.
 - .3 Type 3 Motors (Explosion-proof): The motor shall have Class F insulation. Steel frame motors are not permitted.

2.6 Vertical Motors

- .1 Unless otherwise specified, provide full voltage vertical motors with a Type P base specifically designed for vertical installation.
- .2 Universal position motors are not acceptable.
- .3 Provide vertical motors with solid shafts unless specified otherwise.
- .4 Provide thrust bearing rating compatible with the loads imposed by the driven equipment.

2.7 Submersible Motors

- .1 Submersible motors shall be manufacturer's standard.
- .2 While the general intention is that the motor construction shall be directed towards providing the most economical frame size consistent with these specified requirements, the design and quality of construction shall not be sacrificed in any manner, and a robust motor requiring a minimum of service and maintenance shall be provided.
- .3 Motors shall be in accordance with EEMAC Design Letter B for starting and torque characteristics, EEMAC Code Letter G for in-rush kVA, and CSA Standards.
- .4 Motors shall be sized to always exceed the kilowatt requirements of the pump of submersible mixer at any point on the pump curve by at least 10%.
- .5 Rated for operation at all points on the pump curve without exceeding motor rating.

PROCESS MOTORS LESS THAN 150 KW

- .6 Motor winding, rotor and bearings to be in a sealed submersible type housing, with moisture sensing probe. Motors shall be capable of operating with motor only partially submerged. Normal operating mode will be under fully submerged condition.
- .7 Motors shall be designed for continuous duty, submerged or not fully submerged and shall be capable of 15 spaced starts per hour.
- .8 The motor insulation shall be EEMAC standard, Class F, rated for 155°C.
- .9 The overall motor power factor at full load condition shall not be less than 0.85.
- .10 Provide lifting lugs for full weight of pump and motor.
- .11 Bearings shall be factory pre-lubricated for low maintenance and bearing life shall be not less than AFBMA L-10 life of 70,000 hours.
- .12 Power and control cables shall be sized to match the pump equipment supplied for the specified service conditions, and shall be fully waterproof.
- .13 If the submersible pumps / mixer nominal current exceeds 60 Amps the installing Contractor is responsible for a permanent connection using strain relief, glands, seals and Nema4x junction box and/or ventilated trough.
- .14 Cable shall contain instrument leads, shielded as necessary to prevent electrical interference. Cable shall be heavy duty, water tight, capable of withstanding operating loads. Seal end of cable prior to shipping to prohibit ingress of moisture.
- .15 Provide motor stator protection for each phase winding and leak detection system in the stator chamber. The protection monitoring cables will be connected to the motor monitoring unit (supervision relay) to be installed in the associated motor starter in the electrical room.
- .16 Motor Protection Supervision Relay shall normally be provided by the supplier of the submersible equipment as an integrated component. (e.g. MAS and/or MiniCas units by ITT Flygt). The Supplier should coordinate and confirm they provide the supervision relay as part of the package.
- .17 Pump protection shall be complete with overload, over heat protection, and water entry alarm signal.
- .18 Pump power cords and sensor cords, minimum 17 m in length, shall be potted for submersible rating.
- .19 The control cable shall have the necessary number of conductors for the functions indicated on the schematic diagrams and the process control description. Design cable specifically for submersible applications. Cable shall consist of conductors individually insulated and covered with an outer jacket.
- .20 Pump power cords to include Kellems cable grips to support cables from hooks.

PROCESS MOTORS LESS THAN 150 KW

2.8 Corrosion Prevention and Finish Painting

- .1 Provide equipment resistant to corrosion from severe moisture conditions and exposure to H₂S gas.
- .2 To manufacturer's standards.

2.9 Equipment Identification

- .1 Nameplates:
 - .1 Provide motor nameplates on engraved or stamped stainless steel. Include information enumerated in NEMA Standard MG1, paragraph 10.37, 10.38 or 20.60, as applicable.
 - .2 Additionally, indicate:
 - .1 The ABMA L-10 rated life for the motor bearings for motors 37.5 kW and larger.
 - .2 The nominal efficiency for all motors.
 - .3 Class, division, group and UL frame temperature limit code for explosion-proof motors.
 - .4 Permanently fasten nameplates to the motor frame and position to be easily visible for inspection.

2.10 Spare Parts

- .1 Provide maintenance materials and spare parts.

3. EXECUTION

3.1 Installation

- .1 Dry motor if dampness present, in accordance with Manufacturer's recommendations.
- .2 Install motor on driven machinery rigid plumb and square, using only lifting facilities provided.
- .3 Install or ensure the motor is properly installed to provide satisfactory service.
- .4 Make wiring connections as indicated. Use liquid tight polyvinyl chloride jacketed flexible conduit between rigid conduit and motor.
- .5 Make flexible conduit long enough to permit movement of motor over entire length of slide rails, when applicable.
- .6 Check for correct direction of rotation, with motor uncoupled from driven equipment.
- .7 Align and couple motor to driven machinery to Manufacturer's instructions, using only correct parts such as couplings, belts, sheaves, as provided by the Manufacturer.

PROCESS MOTORS LESS THAN 150 KW

- .8 Install anchor devices and setting templates as recommended by the manufacturer.

3.2 CLEANING

- .1 On completion and verification of performance of installation, remove surplus materials, excess materials, rubbish, tools and equipment.

3.3 Testing

- .1 Perform tests and document results in accordance with Division 26.

END OF SECTION

DRY TYPE TRANSFORMERS UP TO 600 V - PRIMARY

1. GENERAL

1.1 Work

- .1 Provide enclosed dry type transformers 600 V primary to 120/208 V.

1.2 References

- .1 Canadian Standards Association (CSA):
 - .1 CSA C9, Dry-Type Transformers.
 - .2 CSA C22.2, No. 47, Air-cooled transformers (dry type); General Instruction No 1-3.
- .2 National Electrical Manufacturers Association (NEMA):
 - .1 NEMA 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
 - .2 NEMA ICS 6, Industrial Control and Systems: Enclosures.

1.3 Submittals

- .1 Product Data – 3-phase, 4 Wire Secondary.
 - .1 Submit product data in accordance with Section 26 05 00 – Common Work Results For Electrical.
 - .2 Submit operation and maintenance data for dry type transformers for incorporation into manual.

2. PRODUCTS

2.1 Transformers

- .1 General: dry type, air-cooled, self-ventilated, code gauge steel, complete with ventilation openings, removable access panels, mounting brackets, and solderless primary and secondary cable connectors. Enclosures to have zinc chromate prime coat and enamel finish coat per Division 26. Transformers to be single- or 3-phase as noted on the Contract Documents.
- .2 Design:
 - .1 Type: ANN.
 - .2 3-phase, kVA as indicated on the Contract Documents, 600 V input, 120/208 V output, 60 Hz.
 - .3 Voltage primary taps: 2.5% full capacity above and below normal.
 - .4 Insulation: Class H.

DRY TYPE TRANSFORMERS UP TO 600 V - PRIMARY

- .5 Basic Impulse Level (BIL): 10 kV minimum.
- .6 Hipot: 4 kV.
- .7 Average Sound Level: to meet the local municipal and building codes and meet at minimum the following criteria:
 - .1 45 dB maximum up to 45 kVA.
 - .2 50 dB maximum up to 150 kVA.
 - .3 55 dB maximum up to 300 kVA.
 - .4 60 dB maximum above 500 kVA.
- .8 Impedance at 170°C: 6.0% maximum up to 112.5 kVA; 5.5% maximum above 112.5 kVA.
- .9 Enclosure:
 - .1 Removable metal front panel.
 - .2 Nema 3R for outdoor applications and Nema 1 unless specified otherwise.
- .10 Mounting: up to 45 kVA suitable for wall or floor mounting and above 45 kVA suitable for floor mounting unless otherwise shown.
- .11 Finish: In accordance with Division 26.
- .12 Three Phase Windings: arrange with three primary windings connected in delta and three secondary windings connected in wye.
- .13 Max. Winding Temperature: 150°C rise with temperature continuous full load.
- .14 Max. Lead Connection: 55°C rise with temperature continuous full load.
- .15 Copper winding.
- .16 All connections are front accessible only and taps.

2.2 Equipment Identification

- .1 Provide equipment identification in accordance with Division 26.
- .2 Label: Size 7.

2.3 Acceptable Manufacturers:

- .1 Eaton.
- .2 Schneider Electric.

DRY TYPE TRANSFORMERS UP TO 600 V - PRIMARY

- .3 Hammond Manufacturing Co. Inc.
- .4 Delta Transformers.

3. EXECUTION

3.1 Installation

- .1 Ensure adequate clearance around transformer for ventilation.
- .2 Install transformers in level upright position.
- .3 Remove shipping supports only after transformer is installed and just before putting into service.
- .4 Loosen isolation pad bolts until no compression is visible.
- .5 Make primary and secondary connections in accordance with wiring diagram.
- .6 Mount transformers as indicated on Contract Documents and connect primary, secondary, neutral and ground conductors. Provide brackets and bolts for wall mounted transformers. Ensure all transformers have good ventilation.
- .7 Do not use permanent distribution system dry type transformers for temporary power distribution without permission from the Contract Administrator.
- .8 Mount transformers to reduce direct and transmitted noise. Mount core and coils of transformers on vibration and sound absorbing pads. Install vibration insulators between unit and floor/wall where applicable.
- .9 Record secondary voltage when transformers when carrying approximately 75% of full load. Adjust tap connections to give a continuous secondary voltage of 120 V phase to neutral. Set tap connections for above 120 V rather than below.
- .10 Connections to transformers shall be in flexible conduit and shall enter the enclosure below the coils.
- .11 Before energization, keep transformers or storage room enclosures above 10°C ambient.
- .12 Ensure adequate clearance around transformers for ventilation and heat radiation as indicated by Code and manufacturer recommendations, whichever is more stringent.

END OF SECTION

PANELBOARDS - BREAKER TYPE

1. GENERAL

1.1 References

- .1 National Electrical Manufacturers Association (NEMA):
 - .1 NEMA 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
 - .2 NEMA ICS 6, Industrial Control and Systems: Enclosures.

1.2 Shop Drawings

- .1 Submit Shop Drawings in accordance with Section 26 05 00 – Common Work Results For Electrical.
- .2 Drawings to include electrical detail of panel, branch breaker type, quantity, ampacity and enclosure dimension.

2. PRODUCTS

2.1 Panelboards

- .1 Panelboards: Product of one Manufacturer.
 - .1 Manufacturer's nameplate must show fault current that panel including breakers has been built to withstand.
- .2 Enclosure:
 - .1 Refer to Division 26.
 - .2 Finish: Rust inhibitor prime followed by Manufacturer's standard gray baked enamel or lacquer.
- .3 Panelboards: bus and breakers rated for 250 V to be 18 kA, 600 V to be 50 kA (symmetrical interrupting capacity) or as indicated. Series rated breakers not acceptable.
- .4 Sequence phase bussing with odd numbered breakers on left and even on right, with each breaker identified by permanent number identification as to circuit number and phase.
- .5 Panelboards: mains, number of circuits, and number and size of branch circuit breakers as indicated.
- .6 Install breakers in panelboards prior to shipping. Circuit breaker size and position are to match the panelboard schedules.
- .7 Two (2) keys for each panelboard and key panelboards alike.
- .8 Bus:

PANELBOARDS - BREAKER TYPE

- .1 Tin plated Copper bus with neutral of same ampere rating as mains. Full size throughout entire length. Neutral bus rating to be the same ampere rating as the phase bus (fully rated neutral).
- .2 Provide for mounting of future protective devices along full length of bus regardless of number of units and spaces shown. Machine, drill, and tap as required for current and future positions.
- .9 Mains: suitable for bolt-on breakers.
- .10 Trim with concealed front bolts and hinges.
- .11 Trim and door finish: baked grey enamel.
- .12 Transient voltage surge suppressor surge protection – bus connected.
- .13 Panel to be 508 mm wide minimum.
- .14 Isolated ground bus.
- .15 Include grounding busbar with minimum three terminals for bonding conductor equal to breaker capacity of the panelboard.

2.2 Breakers

- .1 Breakers: refer to Division 26.
- .2 Breakers with thermal and magnetic tripping in panelboards except as indicated otherwise.
- .3 Main breaker: separately mounted on top or bottom of panel to suit cable entry. When mounted vertically, down position should open breaker.
- .4 Branch and main breaker to be bolt-on style. Push on or stab-loc style breakers are not acceptable.

2.3 Equipment Identification

- .1 Provide equipment identification in accordance with Division 26.
- .2 Nameplate for each panelboard Size 4 engraved as indicated.
- .3 Nameplate for each circuit in distribution panelboards Size 2 engraved as indicated.
- .4 Complete circuit directory with typewritten legend showing location and load of each circuit, include holder, clear protective cover and removable directory.

2.4 Acceptable Manufacturers

- .1 Eaton.
- .2 Square D (Schneider Electric).

PANELBOARDS - BREAKER TYPE

.3 Siemens.

3. EXECUTION

3.1 Installation

- .1 Locate panelboards as indicated and mount securely, plumb, true and square, to adjoining surfaces.
- .2 Mount panelboards to height specified in Division 26.
- .3 Connect loads to circuits.
- .4 Connect neutral conductors to common neutral bus with respective neutral identified.
- .5 Provide filler plates in unused spaces.
- .6 Provide updated typewritten circuit directory for each panelboard, affixed within each panel. Submit schedules in Microsoft Excel format.
- .7 Identify all spare breakers on breaker directory as "SPARE".
- .8 Loads shall be evenly balanced on all phases where possible.

END OF SECTION

WIRING DEVICES

1. GENERAL

1.1 References

- .1 National Electrical Manufacturers Association (NEMA):
 - .1 NEMA 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
 - .2 NEMA ICS 6, Industrial Control and Systems: Enclosures.
- .2 Canadian Standards Association (CSA):
 - .1 C22.2 NO. 42-10 (R2015) - General use receptacles, attachment plugs, and similar wiring devices.
 - .2 C22.2 NO. 42.1-13 - Cover plates for flush-mounted wiring devices (Bi-national standard, with UL 514D).
 - .3 C22.2 NO. 55-15 - Special use switches.
 - .4 C22.2 NO. 111-10 (R2015) - General-use snap switches (Bi-national standard, with UL 20).

2. PRODUCTS

2.1 Manufacturer

- .1 Wiring devices to be of one (1) manufacture throughout project.
- .2 Acceptable Manufacturers:
 - .1 Arrow-Hart (Cooper/Eaton).
 - .2 Crouse-Hinds (Eaton).
 - .3 Hubbell Inc.

2.2 Devices

- .1 The catalogue numbers shown below are for the particular Manufacturer's series and all necessary suffixes shall be added for the requirements as stated. All devices shall be specification grade minimum.
- .2 Devices to be with stainless steel coverplates in all but mechanical areas unless noted otherwise.
- .3 Use galvanized steel coverplates in mechanical areas and for surface mounted devices.
- .4 Category 2, hazardous locations, and outdoor areas shall use NEMA 4X boxes and coverplates.

WIRING DEVICES

2.3 Switches

- .1 120-277 V, 20 A, single and double pole, three-way and four-way.
- .2 For wet locations use the following switches: 20 A, 120 V single pole, side wired press-switch.
- .3 For Category 2 area, switches shall be marked and CSA approved for use in Category 2 area (NEMA 4X).
- .4 Manually - operated general purpose AC switches shall have the following features:
 - .1 Terminal holes approved for AWG # 10 wire.
 - .2 Silver alloy contacts.
 - .3 Urea or melamine molding for parts subject to carbon tracking.
 - .4 Suitable for back and/or side wiring.

2.4 Receptacles

- .1 Receptacles to be of one manufacturer throughout project.
- .2 Duplex 15 A, 120 V, 3 wire, U-ground, with the following features:
 - .1 White urea molded housing.
 - .2 Suitable for # 10 AWG for back and side wiring.
 - .3 Eight (8) back wired entrances, four (4) side wiring screws.
 - .4 Break-off links for use as split receptacles.
 - .5 Triple wipe contacts and riveted grounding contacts.
- .3 Duplex 15 A, 120 V, 3 wire, U-ground ground fault receptacle.
- .4 Provide coverplates for all wiring devices.
- .5 Use sheet steel utility box cover for wiring devices installed in surface mounted utility boxes.
- .6 Use stainless steel 1 mm thick coverplates on all wiring devices mounted in flush-mounted outlet boxes unless otherwise specified.
- .7 Receptacles located in the wet areas and on the exterior of the building to be weatherproof construction, complete with wet-while-in-use covers.
- .8 Receptacles exposed to weather shall have wet location cover plates complete with "Extra Duty" designation.
- .9 Weatherproof double lift spring-loaded cast aluminum coverplates, complete with gaskets for single receptacles or switches.

WIRING DEVICES

- .10 Weatherproof spring-loaded cast aluminum coverplates complete with gaskets for single receptacles or switches.
- .11 Use gasketed DS cast covers on FS and FD type boxes.
- .12 For Category 2 areas switches shall be marked and CSA approved for use in wet or corrosive area and be NEMA 4X or better.

2.5 Cover Plates

- .1 Cover plates to be of one manufacturer throughout project.
- .2 Provide stainless steel cover plates for all wiring devices.
- .3 Use sheet steel utility box cover for wiring devices installed in surface mounted utility boxes.
- .4 Use stainless steel 1 mm thick cover plates on all wiring devices mounted in flush-mounted outlet boxes unless otherwise specified.
- .5 Weatherproof double lift spring-loaded cast aluminum cover plates, complete with gaskets for single receptacles or switches.
- .6 Weatherproof spring-loaded cast aluminum cover plates complete with gaskets for single receptacles or switches.
- .7 Use gasketed DS cast covers on FS and FD type boxes.

3. EXECUTION

3.1 Installation

- .1 Wherever possible, mount equipment in a straight line at a uniform mounting height, coordinated with other equipment and materials.
- .2 Mounting dimensions are to the centre of the devices. Final instructions on mounting heights shall be given by Contract Administrator at the Site. The above shall be used as a guide, but shall be subject to final verification prior to installation.
- .3 Switches:
 - .1 Install single throw switches with handle in the "UP" position when switch closed.
 - .2 Install switches vertically in gang type outlet box when more than one switch is required in one location.
- .4 Receptacles:
 - .1 Install receptacles vertically in gang type outlet box when more than one receptacle is required in one location.

WIRING DEVICES

- .2 Install receptacles exposed to weather at least 1000 mm above finished grade. Where 1000 mm is not achievable due to site conditions, receptacles shall be mounted facing downward at an angle of 45° from the horizontal.

- .5 Cover Plates:
 - .1 Protect cover plate finish with paper or plastic film until all painting and other Work is finished, and then remove paper.
 - .2 Install suitable common coverplates where wiring devices are grouped. Do not distort plates by tightening screws excessively.
 - .3 Do not use coverplates meant for flush outlet boxes on surface mounted boxes.

END OF SECTION

MOULDED CASE CIRCUIT BREAKERS

1. GENERAL

1.1 References

- .1 National Electrical Manufacturers Association (NEMA):
 - .1 NEMA 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
 - .2 NEMA ICS 6, Industrial Control and Systems: Enclosures.

1.2 Product Data

- .1 Submit product data in accordance with Division 26.
- .2 Include time-current characteristic curves for breakers with minimum symmetrical (rms) interrupting capacity as shown at system voltage.

2. PRODUCTS

2.1 Breakers General

- .1 Moulded case circuit breakers, arc-fault circuit-interrupters, and ground-fault circuit interrupters: to CSA C22.2 No. 5.
- .2 Bolt-On Moulded Case Circuit Breaker: quick-make, quick-break type, for manual and automatic operation with temperature compensation for 40°C ambient.
- .3 Common-Trip Breakers: with single handle for multi-pole applications.
- .4 Magnetic instantaneous trip elements in circuit breakers to operate only when value of current reaches setting. Trip settings on breakers with adjustable trips to range from three (3) to eight (8) times current rating.
- .5 Circuit breakers with interchangeable trips as indicated.
- .6 Breakers shall have a minimum of 25 kA RMS symmetrical interrupting rating at 600 V and 10 kA RMS symmetrical interrupting rating at 120/208 V, or shall match the ratings of the device in which they are installed, whichever is higher.
- .7 Add Electronic trip unit with adjustable settings to meet co-ordination study requirements where applicable or as shown on the Contract Documents.
- .8 New breakers installed in existing panelboards shall be of the same make as the panelboard in which they are installed.

2.2 Thermal Magnetic Breakers

- .1 Moulded case circuit breaker to operate automatically by means of thermal and magnetic tripping devices to provide inverse time current tripping and instantaneous tripping for short circuit protection.

MOULDED CASE CIRCUIT BREAKERS

2.3 Magnetic Breakers

- .1 Moulded case circuit breaker to operate automatically by means of magnetic tripping devices to provide instantaneous tripping for short circuit protection.

2.4 Moulded Case Switch

- .1 Moulded case switch shall be complete with a high instantaneous magnetic fixed trip, factory set to trip at high fault currents.

2.5 Enclosure for Individually Mounted Breakers or Moulded Case Switch

- .1 Enclosure shall be CSA code gauge galvanized steel, hinged door, front mounted external operating handle, lockable in "off" position. Increase enclosure size above standard for large cables. NEMA Type according to Division 26.
- .2 Where distribution system has grounded neutral conductor, provide neutral bar, with ampere rating equal to breaker/switch rating in enclosure.

3. EXECUTION

3.1 Installation

- .1 Install circuit breakers as indicated on Contract Documents and specified herein.
- .2 Install circuit breakers in panel boards to satisfy branch circuit requirements under the Scope of Work of this Contract.
- .3 Identification: Provide lamacoid plate on each breaker showing voltage, source of supply and load being fed - 120/208 V, 3-phase, 4W or 3W as appropriate.

END OF SECTION

DISCONNECT SWITCHES FUSED AND NON-FUSED UP TO 600 V - PRIMARY

1. GENERAL

1.1 Description

- .1 Provide disconnect switches for 347/600 V and 120/208 V distribution as indicated on the Contract Documents.

1.2 References

- .1 National Electrical Manufacturers Association (NEMA):
 - .1 NEMA 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
 - .2 NEMA ICS 6, Industrial Control and Systems: Enclosures.
- .2 Canadian Standards Association:
 - .1 CAN/CSA C22.2 No.4-M89, Enclosed Switches.
 - .2 CSA 22.2 No.39-M89, Fuseholder Assemblies.

1.3 Submittals

- .1 Submit product data in accordance with Specification E6

2. PRODUCTS

2.1 Disconnect Switches

- .1 Ratings: 600 V for 347/600 V distribution, 240 V for 120/208 V distribution. Unless otherwise shown, 3 pole for 3-phase, 3 wire distribution, 3 pole, and solid neutral for 3-phase 4 wire distribution. Ampere ratings as shown on the Contract Documents or to suit load requirements. For motors, use disconnects switches with HP ratings at least equal to motor HP.
- .2 Enclosures: CSA code gauge galvanized steel, hinged doors, external operating handles. Provide ON-OFF switch position indication on switch enclosure cover.
- .3 NEMA Type according to Division 26.
- .4 Finish: one (1) primer coat and one (1) finish coat on all metal surfaces, colours as per Division 26.
- .5 Switch mechanisms: quick-make and quick-break action with self-wiping contacts, solderless pressure lug connectors.
 - .1 For switches 100 A and over, provide non-tracking arc shrouds.
 - .2 All switch poles to operate together from a common operating bar.

DISCONNECT SWITCHES FUSED AND NON-FUSED UP TO 600 V - PRIMARY

- .6 Provide for padlocking disconnect switches in OFF position. Doors to be interlocked and complete with defeat mechanism, to prevent opening when handle in ON position.
- .7 Neutral Bars: where distribution system has grounded neutral conductor, provide neutral bar where required with ampere rating equal to switch rating, in enclosure. Provide ground bar for terminating ground conductors.
- .8 Fuse Holders: provide fuse holders (relocatable and suitable without adapters) on load side of switches, ampere rating equal to switch ratings, suitable for fuses specified.
- .9 Approved Manufacturers:
 - .1 Eaton.
 - .2 Schneider Electric.
 - .3 Siemens.

2.2 Fuses

- .1 All fuses to be 100,000 a (minimum) interrupting capacity of the current limited type. In addition, fuses feeding motors to be of the time delay type. Provide one (1) full set of spare fuses, three (3) for each different ampere rating used, stored in suitable enclosure.

2.3 Equipment Identification

- .1 Provide limacoid for door mount disconnect switches in accordance with 26 05 00 – Common Work Results For Electrical, showing load being fed, voltage, and source of supply, for example:
 - .1 Pump Control Panel.
 - .2 600V, 3-ph.
 - .3 Fed from CDP-A.

3. EXECUTION

3.1 Disconnect Switches

- .1 Mounting: provide supports independent of conduits. Wall-mount where possible, otherwise provided Unistrut frame support. Where switches are grouped mount in uniform arrangement.
- .2 Wiring: connect line and load cable to all switches.
- .3 Fuse Rating: install so that rating is visible.

END OF SECTION

MOTOR STARTERS TO 600 V

1. GENERAL

1.1 References

- .1 National Electrical Manufacturers Association (NEMA):
 - .1 NEMA 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
 - .2 NEMA ICS 2, Industrial Control and Systems Controllers, Contactors, and Overload Relays Rated 600 Volts.
 - .3 NEMA ICS 6, Industrial Control and Systems: Enclosures.

1.2 Shop Drawings and Product Data

- .1 Submit Shop Drawings in accordance with Division 26.
- .2 Indicate:
 - .1 Mounting method and dimensions.
 - .2 Starter size and type.
 - .3 Layout of identified internal and front panel components.
 - .4 Enclosure types.
 - .5 Wiring diagram for each type of starter.
 - .6 Interconnection diagrams.

1.3 Starter Requirements

- .1 Supply separately mounted starters as indicated on the Drawings and wire the equipment.
- .2 Provide interlocking between starters where required.
- .3 All starter accessories such as pilot lights, Hand-Off-Auto, Start-Stop, etc. whether integrally or remote mounted shall be heavy-duty oil tight, unless otherwise specified.

1.4 Operation and Maintenance Data

- .1 Provide operation and maintenance (O&M) data for motor starters for incorporation into manual specified in Division 26.
- .2 Include O&M data for each type and style of starter.

1.5 Maintenance Materials

- .1 Provide listed spare parts for each different size and type of starter:
 - .1 Three (3) contacts, stationary.

MOTOR STARTERS TO 600 V

- .2 Three (3) contacts, movable.
- .3 One (1) contact, auxiliary.
- .4 One (1) operating coil.
- .5 Two (2) fuses.
- .6 10% indicating lamp bulbs used.

2. PRODUCTS

2.1 Materials

- .1 Starters to NEMA ICS 2.

2.2 Manual Motor Starters

- .1 Manual motor starters of size, type, rating, and enclosure type as indicated, with components as follows:
 - .1 Switching mechanism, quick make and break.
 - .2 Overload heaters, manual reset, trip indicating handle.
 - .3 Rated volts and poles to suit application.
- .2 Accessories:
 - .1 Toggle switch or push-button: heavy duty oil-tight labelled as indicated.
 - .2 Indicating lights: heavy duty oil tight type and colour as indicated.
 - .3 Locking tab to permit padlocking in "ON" or "OFF" position.

2.3 Full Voltage Non Reversing (FVNR) Magnetic Starters

- .1 Smallest size starter shall be NEMA size 1 unless otherwise indicated.
- .2 Magnetic and combination magnetic starters of size, type, rating, and enclosure type as indicated with components as follows:
 - .1 Contactor solenoid operated rapid action type.
 - .2 Motor overload protective device in each phase, manually reset from outside enclosure.
 - .3 Wiring and schematic diagram inside starter enclosure in visible location.
 - .4 Identify each wire and terminal for external connections, within starter, with permanent number marking identical to diagram.
 - .5 Hand-Off-Auto switches mounted on starter door.
 - .6 Time delay ON timing relay for staggered starting of motors where required.

MOTOR STARTERS TO 600 V

- .3 Combination type starters to include motor circuit interrupter with operating lever on outside of enclosure to control motor circuit interrupter, and provision for:
 - .1 Locking in "OFF" position with up to three (3) padlocks.
 - .2 Independent locking of enclosure door.
 - .3 Provision for preventing switching to "ON" position while enclosure door open.
- .4 Accessories:
 - .1 Pushbuttons or Selector switches: heavy-duty oil tight labelled as indicated.
 - .2 Indicating lights: heavy duty oil tight type and red pilot light to indicate energized motor circuit and where called for, green pilot light to indicate de-energized motor circuit. Pilot lights to be push-to-test transformer type.
 - .3 In addition to standard, 1-N/O and 1-N/C spare auxiliary contacts unless otherwise indicated.

2.4 Control Transformer

- .1 A control transformer of sufficient VA capacity, dry type, with primary voltage as indicated and 120 V secondary, complete with primary and secondary fuses (HRC Form J), installed in with starter as indicated.
- .2 Size control transformer for control circuit load +20% spare capacity.

2.5 Finishes

- .1 Apply finishes to enclosure in accordance with Division 26.

2.6 Equipment Identification

- .1 Provide equipment identification in accordance with Division 26.
- .2 Manual starter designation label, white plate, black letters, size 1, engraved as indicated.
- .3 Magnetic starter designation label, white plate, black letters, engraved as indicated.

3. EXECUTION

3.1 Starter Verification

- .1 Field check motor starters supplied prior to commissioning equipment.
 - .1 Check of control circuits.
 - .2 Verify that overload relay installed is correctly sized for motor used.
 - .3 Record overload relay size and motor nameplate amperage.
 - .4 Visual inspection of fuses and contactors.

MOTOR STARTERS TO 600 V

- .5 Ensure all connections are tight.
- .2 Measure and record motor amps, under load conditions and compare with full load amps and motor service factor. Report any excessive readings and unbalance. Measure voltage as close to motor terminals as possible while motor is running.
- .3 Set all motor circuit protectors to the minimum level which will consistently allow the motor to start under normal starting conditions.

3.2 Overload Relays

- .1 For starters provided, select overload relays in accordance with relay and motor Manufacturers' recommendations, considering motor service factors, ambient temperature, temperature differences between motor and starter locations. Monitor motor operation during start-up to ensure motor operation is satisfactory and relays provide proper protection. For side inlet fans and other long acceleration time loads, provide special overload relays to suite the start-up condition. Provide manufacturers' curves and data sheets where necessary to provide supporting data for motor protection.

3.3 Field Quality Control

- .1 Perform tests in accordance with Division 26 and Manufacturer's instructions.
- .2 Operate switches, contactors to verify correct functioning.
- .3 Perform starting and stopping sequences of contactors and relays.
- .4 Check that sequence controls, interlocking with other separate related starters, equipment, control devices, operate as indicated.

END OF SECTION

PROCESS CONTROL NARRATIVE

1. PROCESS CONTROL NARRATIVE

1.1 Storm Sump Upgrade

.1 Overview

- .1 The Deacon Booster Pumping Station (DBPS) will be upgraded to ensure that plant flooding response is coordinated between the storm sump (located on the west side of the DBPS) and sanitary sump (located on the east side of the DBPS). This will be achieved by installation of a new high-high level float (LSHH-93605) in the west sump set to match the elevation of the east sump station flood lockout float, LSH-D5432. Activation of either LSHH-93605 or existing LSH-D5432 will trigger the station lockout procedure.
- .2 To protect the DBPS from excess inflows into the west storm sump, new actuated valves will be installed on all three incoming sump lines. A new high level float will be added. Once the float triggers, the new valves will close to prevent flooding within the sumps.

.2 Control Components

.1 DBPS Station Flood Lockout will involve the following devices:

- .1 The existing east sump high-high level/station flood lockout float (LSH_5432).
- .2 A new west sump high-high level/station flood lockout float (LSHH-93605)

.2 The DBPS Storm Sump Valve controls will involve the following devices:

- .1 New butterfly valves (LV-93601, LV-93602 and LV-93603), and their associated hand and limit switches, servicing each of the three incoming lines to the sump.
- .2 A new valve close/high level float in the west sump (LSH-93604)

.3 Related Documents:

- .1 1-601B-P0001-001
- .2 1-0601D-P0020
- .3 1-0601D-C0005-001
- .4 1-0601D-E0004-001
- .5 Section E12 – Chamber Piping and Appurtenances
- .6 Specification 40 95 13 – Control Panels

PROCESS CONTROL NARRATIVE

.4 Narrative:

.1 DBPS Station Flood Lockout

.1 When LSHH-93605 activates, the resulting LAHH will be used as an “OR” input with the existing storm sump LSH-D5432 (DMZ_943_LAHH) signal to start the station’s flood protection shutdown procedure. Programming to incorporate this new signal within the existing plant logic will be completed by others.

.2 DBPS Storm Sump Valves

.1 Once LSH-93604 activates, the following occurs in the west sump:

.1 Valve (LV-93601) will close.

.2 Valve (LV-93602) will close.

.3 Valve (LV-93603) will close.

.2 Once the associated LAH-93604 condition has passed, the valves will remain closed. The Supervisory Control and Data Acquisition (SCADA) system will not be capable of automatically re-opening the valves. Operators will be required to attend to the valve location to inspect the cause of the alarm and locally reset the valves to the open position via a local control station near the sump.

.3 If the plant control system does not see a “valve closed” confirmation signal following a preset time after sending a close command signal, a “Failure to close” alarm will appear on the plant HMI.

.5 Table of setpoints and alarms:

.1 Values are initial guidelines. Final values to be selected during commissioning.

Name	Device	Description	Setpoint
DBPS Station Flood Lockout			
LAHH-93605	LSHH-93605	West station shutdown alarm	Same elevation as LSH D5432 (east station flood lockout float) as measured from top of floor. Approximate distance below floor of 0.6 m to be confirmed on site.

PROCESS CONTROL NARRATIVE

Name	Device	Description	Setpoint
DBPS Storm Sump Valves			
LAH-93604	LSHH-93604	West sump high alarm/valve close	224.7 m, or 0.48 m above the existing LS2 storm sump float (to be confirmed on site)
XA-93601	LV-93601	Valve LV-93601 has failed to close.	Absence of valve closed confirmation after travel time + 2s has elapsed following close command.
XA-93602	LV-93602	Valve LV-93602 has failed to close.	Absence of valve closed confirmation after travel time + 2s has elapsed following close command.
XA-93603	LV-93603	Valve LV-93603 has failed to close.	Absence of valve closed confirmation after travel time + 2s has elapsed following close command.

1.2 Manhole Pumping Upgrade

.1 Overview

- .1 The manhole pumping upgrade will lower the ground water levels at the Deacon site. Lower levels will reduce hydrostatic stress on foundation walls as well as prevent floatation and uplift on foundation walls. The two Water Treatment Plant (WTP) weeping tile manholes will each have a submersible pump with on/off float controls, a high-high level alarm and a pump fault alarm. Local control panels will provide the control logic for the pumps. The high-high level alarm and pump fault signals will be reported back to plant SCADA.

.2 Control Components

- .1 The WTP Weeping Tile Manhole Pumping Upgrade controls will involve the following devices for the existing Filter/Ozone/Residual Weeping Tile Manhole (MH-FOR):
 - .1 Low level float switch LSL-5013
 - .2 High level float switch LSH-5014
 - .3 High-high level float switch LSHH-5015
 - .4 New pump P-Y501
- .2 The WTP Weeping Tile Manhole Pumping Upgrade controls will involve the following devices for the existing Raw Water Pump Station Manhole (MH-RWPS):
 - .1 Low level float switch LSL-5023
 - .2 High level float switch LSH-5024

PROCESS CONTROL NARRATIVE

- .3 High-high level float switch LSHH-5025
- .4 New pump P-Y502
- .3 Related Documents:
 - .1 1-0601B-P0002-001
 - .2 1-0601B-P0001-001
 - .3 1-0601B-C0004-001
 - .4 1-0601D-E0003-001 & -002
 - .5 Specification E11 – Chamber Piping and Appurtenances
 - .6 Specification E12 – Submersible Pumps
 - .7 Specification 40 95 13 – Control Panels
- .4 Narrative
 - .1 The following control description is identical for both manholes.
 - .1 Upon activation of the high level float, the pump shall start and run.
 - .2 Once the high level float deactivates and the low level float activates, the pump shall stop.
 - .3 When the high-high float activates, the control panel shall send a “manhole high level” alarm to the plant SCADA.
 - .4 If the pump fails to run due to overload, overtemperature or leakage, the control panel shall send a fault signal to the plant SCADA.
 - .5 Table of alarms provided to SCADA:

Name	Device	Description	Setpoint
LAHH-5015	LSHH-5015	Manhole FOR high-high level alarm	233.0m
LAHH-5025	LSHH-5025	Manhole RWPS high-high level alarm	233.0m
XA-5011	CP-Y700	Manhole FOR pump fault	N/A
XA-5021	CP-Y701	Manhole RWPS pump fault	N/A

- .6 Refer to the related P&IDs for additional float setpoints.

END OF SECTION

LEVEL MEASUREMENT

1. GENERAL

1.1 Reference

- .1 International Society of Automation (ISA):
 - .1 S5.1: P&IDs and Tagging.
 - .2 S5.4: Instrument Loop Diagrams.
 - .3 S7: Instrument Air.
 - .4 S12: Electrical Equipment for Hazardous Locations.
 - .5 S18.2: Alarm Management.
 - .6 S20: Instrument Specifications.
 - .7 S50: Electrical Control Signals.
 - .8 S75: Control Valve Design, Specification and Testing.
 - .9 S96: Valve Actuators.
 - .10 S99: Control System Cyber Security.
 - .11 101: Human-Machine Interfaces.

2. PRODUCTS

2.1 Level Switch, Float

- .1 Float level switches provided for this project shall all be sourced from the same manufacturer and in compliance with this Specification.
 - .1 Float switches shall have SPDT output contacts rated for pilot duty.
 - .2 Provide polypropylene float casing with pre-terminated signal cable. Float switch density shall be selected for optimal performance in the specified process liquid.
- .2 Extension cable shall be three (3) conductor, of sufficient length to reach the ventilated trough without strain and providing adequate slack. A minimum of 15m of cable shall be provided.
- .3 General:
 - .1 Approvals: CSA or cUL
- .4 Function: Actuate contact at preset liquid level.
- .5 Type: Direct-acting float with an enclosed switch and integral cable.
- .6 Service: Wastewater, unless otherwise noted.

LEVEL MEASUREMENT

- .7 Performance:
 - .1 Set Point: As noted.
 - .2 Temperature: -40°C to 50°C.
- .8 Features:
 - .1 Entire Assembly: Watertight and impact-resistant.
 - .2 Float Material and Size: Polyethylene/foam filled; 114 mm diameter max.
 - .3 Suitable for installation in Zone 2 location, or provided with accessories (intrinsically safe barriers) that have been certified with the float switch to form a Zone 2 compliant device.
- .9 Signal Interface:
 - .1 Switch Type: Mercury free
 - .2 Switch Contacts: Form C Dry Contact rated 4.5 A continuous at 120 VAC
- .10 Accessories required for each float:
 - .1 Float sway control ring
 - .2 Hook for cable suspension suitable for anchoring in concrete manhole top slab
 - .3 Kellems cable grip to support cable from hook
- .11 Manufacturer:
 - .1 Xylem ENH-10
 - .2 Or approved equal.

END OF SECTION

INSTRUMENTATION AND CONTROL FOR PROCESS SYSTEMS

1. GENERAL

1.1 Summary

- .1 This Section gives general requirements for Instrumentation and Control related items. It is supplemental to the requirements defined in other Specification Sections.
- .2 Comply with latest edition of all applicable codes and standards whether referenced in this Section or not.
- .3 In the event any inconsistency is discovered between the Specifications, codes or standards, the most stringent shall apply.

1.2 References

- .1 The following is a list of codes and standards are applicable as required:
 - .1 Institute of Electrical and Electronics Engineers (IEEE):
 - .1 C62.41, Recommended Practice on Surge Voltages in Low-Voltage AC Power Circuits.
 - .2 The International Society of Automation (ISA):
 - .1 S5.1, Instrumentation Symbols and Identification.
 - .2 S50.1, Compatibility of Analog Signals for Electronic Industrial Process Instruments.
 - .3 62443, Security for Industrial Automation and Control Systems.
 - .3 Canadian Standards Association (CSA):
 - .1 C22.1 Canadian Electrical Code.
 - .2 C22.2, Electrical Safety Code.
 - .4 National Electrical Manufacturers Association (NEMA).
 - .5 National Fire Code, National Fire Protection Association (NFPA).
 - .1 NFPA 820, Fire Protection in Wastewater Treatment Plants.
 - .6 City of Winnipeg
 - .1 Electrical Design Guide
 - .2 Automation Design Guide
- .2 Complete installation in accordance with the latest version of CSA C22.1.
- .3 Comply with all laws, ordinances, rules, regulations, codes, and orders of all Authorities Having Jurisdiction relating to this Work.

INSTRUMENTATION AND CONTROL FOR PROCESS SYSTEMS

1.3 Acronyms and Abbreviations

- .1 CP: Control Panel
- .2 DCS: Distributed Control System
- .3 FAT: Factory Acceptance Test
- .4 FOCS: Fibre Optic Communication Subsystem
- .5 HVAC: Heating, Ventilating, and Air Conditioning
- .6 I&C: Instrumentation and Control
- .7 I/O or IO: Input and Output
- .8 HMI: Human-Machine Interface, alias for Operator Interface
- .9 LCP: Local Control Panel
- .10 MCC: Motor Control Center
- .11 O&M: Operation and Maintenance
- .12 OWS Operator Work Station
- .13 PC: Personal Computer
- .14 PCS: Process Control System comprising PLC's, and HMIs, communications systems and related hardware and software
- .15 PCU: Process Control Unit, a DCS subsystem
- .16 PICS: Process Instrumentation and Control System
- .17 P&ID: Process and Instrument Diagram.
- .18 PLC: Programmable Logic Controller
- .19 SAT: Site Acceptance Test
- .20 SIT: Site Integration Test
- .21 SIFT: System Integration Functional Test
- .22 UPS: Uninterruptible Power Supply
- .23 VFD: Variable Frequency Drive

INSTRUMENTATION AND CONTROL FOR PROCESS SYSTEMS

1.4 Submittals

.1 General:

- .1 Submit proposed Submittal breakdown list consisting of all PICS component submittals. Sequencing and packaging of information to be in accordance with Progress Schedule.
- .2 Partial Submittals not in accordance with Progress Schedule will not be accepted.
- .3 Obtain Contract Administrator's approval if Submittals for a PICS subsystem are to be made in multiple packages.
- .4 Provide submittals sufficiently in advance of requirements to allow ample time for review.

.2 Shop Drawings and Product Data:

- .1 Prior to delivery of any Products to job site, submit Shop Drawings and Product Data as specified in –Specification E6 for all equipment as required in the Specifications
- .2 Prior to submitting the Shop Drawings to the Contract Administrator, the Contractor shall review the Shop Drawings to determine that the equipment complies with the requirements of the Specifications and Drawings.
- .3 The term “Shop Drawing” means drawings, diagrams, illustrations, schedules, performance characteristics, brochures and other data, which are to be provided by the Contractor to illustrate details of a portion of the Work. Indicate materials, methods of construction and attachment of support wiring, diagrams, connections, recommended installation details, explanatory notes and other information necessary for completion of Work. Where equipment is connected to other equipment, indicate that such items have been coordinated, regardless of the section under which the adjacent items will be supplied and installed. Indicate cross-references to design drawings and Specifications. Adjustments made on Shop Drawings by the Contract Administrator are not intended to change the contract price. If adjustments affect the value of the Work, state such in writing to the Contract Administrator prior to proceeding with the Work.
- .4 Equipment identifiers shall be included on all Shop Drawing and product data submittals to clearly identify the equipment they apply to.
- .5 Manufacture of Products shall conform to revised Shop Drawings.

.3 Informational Submittals:

- .1 Provide informational submittals in accordance with other Specification Sections including but not limited to the following:
 - .1 Training Plan: In accordance with other Specification Sections.
 - .2 Testing and Commissioning Forms: In accordance with other Specification Sections.
 - .3 Operation and Maintenance Data: In accordance with the following:
 - .1 Outline of O&M data.

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.2 Sufficient detail to allow operation, removal, installation, adjustment, calibration, maintenance and purchasing replacements for each PICS component.

.2 Extra Materials:

.1 List of proposed spares, expendables, and test equipment. Separate Submittals for each PICS subsystem.

.2 Recommended Spare Parts: List of, and descriptive literature for, additional spares, expendables, and test equipment recommended by PICS Integrator. Include quantities, unit prices, and total costs.

1.5 Drawings and Specifications

.1 The intent of the Drawings and Specifications is to indicate labor, products, and services necessary for a complete, installed, tested, commissioned and functional installation.

.2 PICS drawings may indicate approximate route to be followed by conduits and cables and general location of electrical equipment. They do not show all structural, architectural and mechanical details. The details on exact cable or conduit routing, and exact equipment installation location is to be determined on site and coordinated with all other trades.

.3 To provide sufficient detail and maximum degree of clarity on the drawings, symbols used for various electrical devices, particularly wall mounted devices, take up more space on the drawings than devices physically do. Locate devices with primary regard for convenience of operation, accessibility and space utilization, rather than locating devices to comply with the exact scaled locations of the electrical symbols.

.4 The PICS Specifications and Drawings and the Specifications of all other Divisions shall be considered as an integral part of the Work. Any item or subject omitted from either the Specifications or the drawings but which is mentioned or reasonably specified by the drawings or Specifications of other Divisions, shall be considered as properly and sufficiently specified and shall be provided.

.5 If discrepancies or omissions in the drawings or Specifications are found, or if the intent or meaning is not clear, advise the Contract Administrator for clarification before submitting a bid.

.6 Provide all minor items and work not shown or specified but which are reasonably necessary to complete the work.

.7 Various package unit types of equipment are included in the Work. It is the responsibility of the Contractor to familiarize himself with the requirements of the equipment vendor, and to include all materials and labor for a complete and working installation. In some cases this means that control panels, instruments, actuators, etc. need to be wired and connected in the field. The Contractor shall include all costs to perform such services as part of his Tender submittal. Coordination between the equipment vendor and the contractor shall be performed prior to tender bid closing date, and all costs shall be included in the tender. Request for extras due to lack of coordination between the Contractor and the equipment vendors will not be accepted.

.8 Cables schedules/lists where shown do not include all cables required to perform the complete facility installation. They shall be used as a general guide. Accurate cable lists, quantities, take-offs remain the responsibility of the Contractor.

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1.6 Care, Operation and Start-Up

- .1 Instruct City's maintenance and operating personnel in the operation, care and maintenance of systems, system equipment and components.
- .2 Where services of a manufacturer's factory service engineer is required, arrange and pay for services to supervise start-up of installation, check, adjust, balance and calibrate components and instruct operating personnel.
- .3 Provide these services for such period, and for as many visits as necessary to put equipment in operation, and ensure that operating personnel are conversant with all aspects of its care and operation.

1.7 Permits, Fees and Inspection

- .1 The Contract Administrator will submit to Electrical Inspection Department and Supply Authority necessary number of drawings and Specifications for examination and approval prior to commencement of Work.
- .2 The Contractor shall pay associated fees as required by the Electrical Inspections and Permitting department.
- .3 Notify the Contract Administrator of changes required by Electrical Inspection Department prior to making changes.
- .4 Furnish a Certificate of Final Inspection and approvals from inspection authority to the Contract Administrator.

1.8 Materials and Equipment

- .1 Provide materials and equipment in accordance with Specifications.
- .2 Equipment and material to be CSA or cUL certified. Where there is no alternative to supplying equipment which is not CSA certified, obtain special approval from Electrical Inspection Department.
- .3 Minimum enclosure type to be used is NEMA 12 unless otherwise specified.
- .4 Junction Boxes:
 - .1 All field wiring connections to be located in junction boxes with terminals. The design documents show the expected junction boxes to be required. However, the Contractor must provide all junction boxes required, whether or not the junction boxes are shown in the design documents.

1.9 PICS Coordination

- .1 Coordinate Work with all other trades to ensure that conflicts do not occur.
- .2 Coordinate requirement of mechanical equipment requiring electrical connection with the mechanical contractor.

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1.10 Finishes

- .1 Shop finish metal enclosure surfaces by application of rust resistant primer inside and outside, and at least two (2) coats of finish enamel.
 - .1 Paint enclosures light grey to ANSI 61 grey enamel, unless otherwise specified.
- .2 Clean and touch-up surfaces of shop-painted equipment scratched or marred during shipment or installation, to match original paint.
- .3 Clean and prime exposed non-galvanized hangers, racks and fastenings to prevent rusting.

1.11 Equipment Identification

- .1 Identify PICS equipment with nameplates.
- .2 Nameplates:
 - .1 Lamacoid, 3 mm thick plastic nameplates, mechanically attached with self tapping stainless steel screws, white face with black lettering. Note: "Sheet Metal Screws" or other sharp pointed screws are NOT acceptable.
- .3 Sizes as follows:

NAMEPLATE SIZES			
Size 1	10 x 50 mm	1 line	3 mm high letters
Size 2	12 x 70 mm	1 line	5 mm high letters
Size 3	12 x 70 mm	2 lines	3 mm high letters
Size 4	20 x 90 mm	1 line	8 mm high letters
Size 5	40 x 90 mm	2 lines	8 mm high letters
Size 6	25 x 100 mm	1 line	12 mm high letters
Size 7	25 x 100 mm	2 lines	5 mm high letters
Size 8	35 x 100 mm	3 lines	5 mm high letters
Size 9	45 x 100 mm	4 lines	5 mm high letters
Size 10	75 x 160 mm	3 or 4 lines	8 mm high letters
Size 11	150 x 250 mm	3 or 4 lines	10 mm high letters

- .4 Wording on nameplates to be approved by Contract Administrator prior to manufacture.
- .5 Allow for average of fifty (50) letters per nameplate.
- .6 Identification to be in English.
- .7 Provide nameplates for the following, sizes as shown:
 - .1 Cabinets – Size 8.
 - .2 Small Junction Boxes (150 mm x 150 mm or smaller) – Size 1.
 - .3 Large Junction Boxes – Size 2.
 - .4 Control panels – Size 8.

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.5 Field Devices (Instruments, Actuators, etc.) – Size 4.

1.12 Wiring Identification

- .1 Identify wiring with permanent indelible identifying markings on both ends as shown on Drawings.
- .2 Wire tags to be heat shrink type with mechanically printed black letters on white background.

1.13 Conduit and Cable Identification

- .1 Colour code conduits, boxes and cables.
- .2 Code with plastic tape or paint at points where conduit or cable enters wall, ceiling, or floor, and at 5 m intervals.
- .3 Colours: 38 mm wide prime colour and 19 mm wide auxiliary colours.

System	Prime Band	Aux. Band
Medium Voltage (>750 V)	Orange	
347/600 V	Yellow	
120/208/240 V Power	Black	
UPS 120/208/240 V Power	Black	Green
Control Wiring (120 V)	Black	Orange
Fire Alarm	Red	
Low Voltage Communication/General	Blue	
Low Voltage Control Wiring (<50 V)	Blue	Orange
Intrinsically Safe	Blue	White
Ground	Green	
Fibre Optic	Purple	

- .4 Cable Identification: Supply and install lamacoid type cable identification tags for all cables. Install identification tag at both ends.

1.14 As-Built Drawings and Documents

- .1 The Contractor shall keep one (1) complete set of white prints at the Site during the work, including all addenda, change orders, Site Instructions, clarifications, and revisions for the purpose of As-Built Drawings. As the Work on-site proceeds, the Contractor shall clearly record in Red Pencil all as-built conditions, which deviate from the original Contract Documents.
- .2 The Contractor shall keep one completed set of automation documents at the Site during the work, including all addenda, change orders, Site Instructions, clarifications, and revisions for the purpose of As-Built documents. This includes, but is not limited to the following:
 - .1 I/O Lists.
 - .2 Instrument Lists.
 - .3 IP Address Lists.
 - .4 Functional Requirements Specifications.

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- .5 Automation Equipment List.
- .6 PLC Module List.
- .3 On completion of the work, minimum of four (4) weeks prior to final inspection, submit As-Built drawings and documents to Contract Administrator for review. The Contractor shall certify, in writing signed and dated, that the As-Built drawings are complete and that they accurately indicate all electrical services, including exposed as well as concealed items.
- .4 After commissioning the Contractor shall transfer all changes to a single set of drawings.
- .5 Obtain a CAD set of drawings (wiring & control diagrams) from AECOM and use professional services for CAD and transfer the "As-Built" condition for all components on those drawings.
- .6 No Substantial Performance shall be issued until final "Record Drawing" CAD files and one set of prints have been received and accepted by the Contract Administrator.

1.15 Operations and Maintenance (O&M) Manuals

- .1 Provide operation and maintenance manuals as specified herein.
- .2 Include in the operations and maintenance manuals a minimum of:
 - .1 Cover page including project name, year, name of owner and electrical consultant. Cover page shall be enclosed in a clear plastic cover.
 - .2 Index.
 - .3 List of manufacturers and supplier for all items.
 - .4 Names, address and phone number of all local suppliers for items included in maintenance manual.
 - .5 Stamped and signed Shop Drawings.
 - .6 Details of design elements, construction features, component function and maintenance requirements, to permit effective start-up, operation, maintenance, repair, modification, extension and expansion of portions or features of the installation.
 - .7 Technical data, product data, supplemented by bulletins, component illustrations, exploded views, technical descriptions of items and parts lists. Advertising or sales literature not acceptable.
 - .8 All test results performed. This includes, but is not limited to fibre optic tests; Control System network tests; Profibus Network Tests; FAT, SIFT, SIT and SAT tests.
 - .9 As-Built drawings.
 - .10 Signed and dated warranty certificate.
 - .11 Signed and dated approval by the local Electrical Inspections Department.
 - .12 All other requirements outlined in the Specifications.

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- .3 Submit draft document prior to the start of commissioning.

1.16 Environmental Conditions

- .1 Equipment and systems are to be rated to correctly operate in the environment in which they are to be installed.
- .2 Exterior devices shall be rated to operate in an exterior environment with temperature range of minus 40°C to plus 40°C.

1.17 Quality Assurance

- .1 Qualifications:
 - .1 For work involving specialties, including, but not limited to, the installation of sound and intercommunication systems, fire alarm systems, lightning protection systems, grounding systems, instrumentation, controls, electronic access, security systems, fibre optics systems, etc. employ only workers fully trained, qualified and experienced in the aspects of such work.

2. PRODUCTS

2.1 General

- .1 The design is based upon the manufacturers and model numbers shown on the drawings and in the Specifications. If a manufacturer chosen after project award is different from that on which the design is based, the design must be modified by the Contractor based on the chosen manufacturer. If additional engineering work is required, the Contractor must provide an Engineer's seal for the change to the design.
- .2 Substitutes:
 - .1 Provide all additional and modified wiring, raceway, enclosures, intrinsically safe barriers, and accessories at no additional cost associated with approved substitutes.
- .3 Like Equipment Items:
 - .1 Use products of one manufacturer and of the same series or family of models to achieve standardization for appearance, operation, maintenance, spare parts, and manufacturer's services.
 - .2 Implement all same or similar functions in same or similar manner. For example, control logic, sequence controls, and display layouts.

3. EXECUTION

3.1 Preparation and Protection

- .1 Schedule expediting of materials and execution of Work in conjunction with associated work of other trades in order to meet the required work schedule.
- .2 Post engraved warning signs to meet requirements of local by-laws, Inspection Authority and Contract Administrator.

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- .3 Protect those working on or in vicinity of exposed electrically energized equipment from physical danger. Shield and mark live parts in accordance with local regulations. Indicate the appropriate voltage.
- .4 Arrange for installation of temporary doors, barriers and similar items for access to rooms and areas containing electrical equipment. Keep these doors locked at all times, except when under direct supervision.
- .5 Permanently identify with lamacoid nameplate, equipment energized from multiple power sources, noting voltages, power source locations, supply disconnect designations and grounding electrode location.

3.2 Warning Signs

- .1 As specified and to meet the requirements of Electrical Inspection Department and the Contract Administrator.
- .2 Lamacoid 3 mm thick plastic engraving sheet, red face, white core, mechanically attached with self tapping stainless steel screws, 20 mm text.

3.3 Mounting Heights

- .1 Unless otherwise noted, or in contravention of codes and standards, mount equipment replacing existing equipment at the same height.
- .2 Mounting height of equipment is from finished floor to centerline of equipment unless specified or indicated otherwise.
- .3 Typical mounting heights are as follows:
 - .1 Wall mounted instruments: 1.5 m Above Finished Floor (AFF)
 - .2 Wall mounted junction boxes: 1.5 m AFF
 - .3 Wall mounted small panels: 1.5 m AFF
 - .4 Wall mounted large panels: Top of cabinet at 2.0 m AFF
 - .5 Gas detection horns and strobes: 2.0 m to 4.0 m AFF
 - .6 Motor control hand switches: 1.5 m AFF
 - .7 Valve actuator control stations: 1.5 m AFF
- .4 If mounting height of equipment is not indicated, verify with the Contract Administrator before proceeding with the installation.

3.4 Modifications to Existing Cabinets

- .1 Where significant modifications are made to existing cabinets, the cabinet shall be inspected by the Authority Having Jurisdiction.

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3.5 IP Addresses

- .1 IP Addresses will be provided to the Contractor for all network devices after project award. The Contractor will be required to sign a Non-disclosure Agreement and confidentiality agreement in relation to the IP Addresses.

3.6 Devices with Integral Leads

- .1 For devices with integral leads, if the location of the device does not allow the leads to reach the junction box as shown on the Drawings, provide additional wiring, conduit and boxes as required to extend the leads to the associated junction box.

3.7 Location of Devices

- .1 Allow for change of location of devices at no extra cost or credit, provided that the distance does not exceed 3000 mm (10') from that shown on the drawings, when the requirement is made known prior to installation.

3.8 Conduit and Cable Installation

- .1 Sleeves through concrete: schedule 40 galvanized steel pipe, sized for free passage of conduit.
- .2 For wall, partitions, and ceilings the sleeve ends shall be flush with the finish on both sides but for floors they shall extend 25 mm (1") above finished floor level.
- .3 Fire stop opening with ULC approved assembly for the installation conditions.
- .4 Provide a detailed proposed conduit routing plan to the Contract Administrator prior to proceeding with the installation of conduit.
- .5 If possible, avoid routing conduits through hazardous area.
- .6 Separate cables of different voltage levels when cables are installed parallel to each other.

3.9 Cutting, Patching, and Drilling

- .1 Provide all cutting and patching as required.
- .2 Return exposed surfaces to an as-found condition.
- .3 Exercise care where cutting/drilling holes in existing concrete elements so as not to damage existing reinforcing, or any other systems run in the concrete.
 - .1 Locate reinforcing and other existing systems using ground penetrating radar, X-Ray or other suitable means. Mark out on the surface of the concrete the locations of rebar and all other systems.
 - .2 For all holes larger than 50 mm passing through reinforced concrete, mark the location of the desired hole and all embedded systems. Obtain approval from the Contract Administrator prior to cutting.
- .4 Firestop and seal all penetrations.

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- .5 Ensure that water ingress will not occur.
- .6 Provide expansion joints for penetrations where shifting can occur.

3.10 Anchor Installation

- .1 The Contractor shall exercise care where installing anchors into existing concrete elements so as not to damage existing reinforcing. All anchors shall be installed utilizing carbide tip drill bits. The existing reinforcing shall be located utilizing a reinforcing bar locator and marked out on the surface of the concrete. The drill holes shall be advanced to the required depth for installation of the anchors. Should reinforcement be encountered while drilling, the hole shall be terminated and repositioned to clear the reinforcement. Do not use core bits that can easily intercept and damage/cut the reinforcing during drilling.

3.11 Field Quality Control

- .1 All electrical work to be carried out by qualified, licensed electricians or apprentices as per the conditions of the Provincial Act respecting manpower vocational training and qualification. Employees registered in a provincial apprentices program shall be permitted, under the direct supervision of a qualified licensed electrician, to perform specific tasks - the activities permitted shall be determined based on the level of training attained and the demonstration of ability to perform specific duties. A maximum of one apprentice is permitted per qualified electrician.
- .2 The work of this division to be carried out by a contractor who holds a valid Master Electrical contractor license as issued by the Province of Manitoba.

3.12 Touch-Up Painting

- .1 Clean and touch-up surfaces of shop painted equipment scratched or marred during shipment or installation, to match original paint.
- .2 Obtain necessary touch-up paint of original type and quality from equipment manufacturer.
- .3 Clean surfaces to be painted. Feather out edges of scratch marks. Make patch inconspicuous.
- .4 Apply one or more coats until damaged surface has been restored to original finish condition.
- .5 Clean and prime exposed non galvanized hangers, racks and fastenings to prevent rusting.
- .6 Do not paint nameplates, tags, CSA labels, warning plates and operating instructions. Observe field painting of electrical equipment or raceways. Labels shall be visible and legible after the equipment is installed.

3.13 Cleaning

- .1 Clean construction debris and materials from enclosures, before final electrical tests. Vacuum the interior and exterior of enclosures to ensure all equipment is free from debris. No loose items shall be in the bottom of cabinet before the final electrical tests. Any spare parts, drawings, documentation, etc. should be stored in the appropriate area in the cabinet.

3.14 Provision for Future Expansion

- .1 In each location where space for future equipment is indicated, leave such space clean. Install conduit, wiring and other work in such a manner that necessary connections can be made in

INSTRUMENTATION AND CONTROL FOR PROCESS SYSTEMS

future without dismantling existing equipment, raceways or wiring. Consult with Contract Administrator whenever necessary.

END OF SECTION

INSTRUMENT STANDARD DETAILS

1. GENERAL

1.1 References

- .1 Section 40 90 00

1.2 Installation Diagrams

- .1 The drawings listed below (bound separately), show typical instrument installation details for each type of instrument specified. The Contractor must review each installation detail together with the reviewed shop drawings for the respective equipment and modify the details if required to comply with the selected equipment manufacturer's requirements.

AILD-A001	Manhole Level Switch High and Low
AILD-A002	DBPS Level Switch High and Low

- .2 Record all modifications to the instrument installation details to as-constructed status and include copies of each in the as-constructed drawing set. Where details are typical, provide updated copies specific to each unique instrument.

2. PRODUCTS (NOT USED)

3. EXECUTION (NOT USED)

END OF SECTION

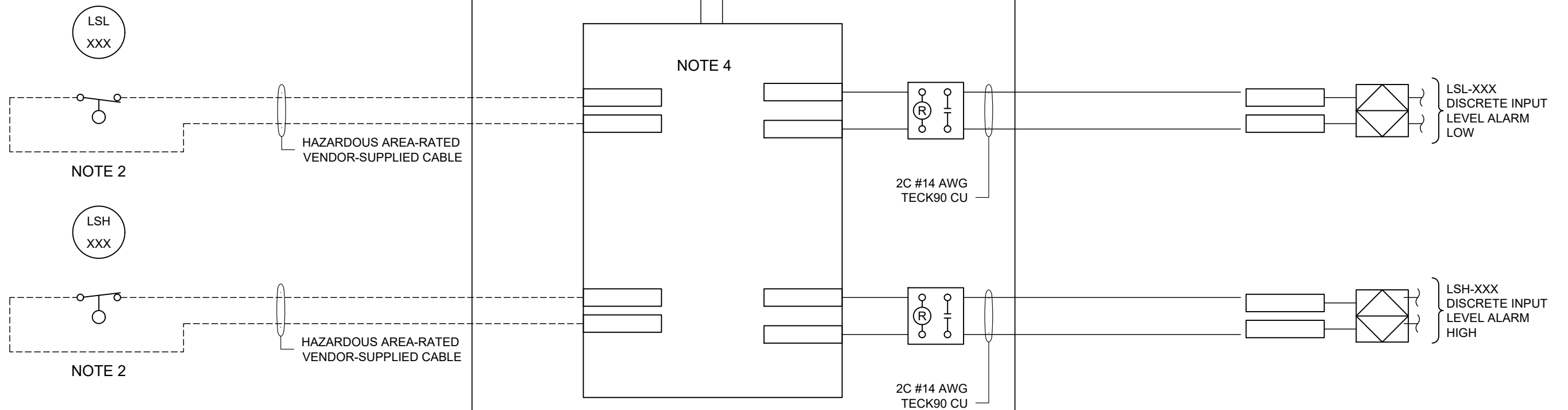
INSTRUMENT LOOP DIAGRAM

FIELD PROCESS AREA

LOCAL CONTROL PANEL

NOTE 3

PLC PANEL



NOTES

1. PROVIDE FIELD JUNCTION BOX AS REQUIRED.
2. CONNECT TO "NORMALLY CLOSED" CONTACTS FOR ALARMS AND "NORMALLY OPEN" CONTACTS FOR EQUIPMENT STATUS, ETC.
3. REFER TO PANEL SCHEMATIC DRAWING 1-0601B-E0004 FOR CONNECTIONS TO CP-Y700 AND CP-Y701.
4. PROVIDE INTRINSICALLY SAFE BARRIERS AND INTERPOSING RELAY ON OUTPUT OF BARRIER FOR CONNECTION TO PLC.

ISSUE/REVISION

I/R	DATE	DESCRIPTION
PB	2022.09.06	ISSUED FOR CONSTRUCTION
PA	2022.07.18	ISSUED FOR 90% REVIEW

CONSULTANT

AECOM Canada, Ltd.
 99 Commerce Drive
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 www.aecom.com



PROJECT

CITY OF WINNIPEG,
 DEACON FLOOD
 PROTECTION UPGRADE

SHEET TITLE

INSTRUMENT LOOP DIAGRAM
 TYPICAL WIRING DIAGRAM
 MANHOLE LEVEL SWITCH HIGH & LOW

SHEET NUMBER

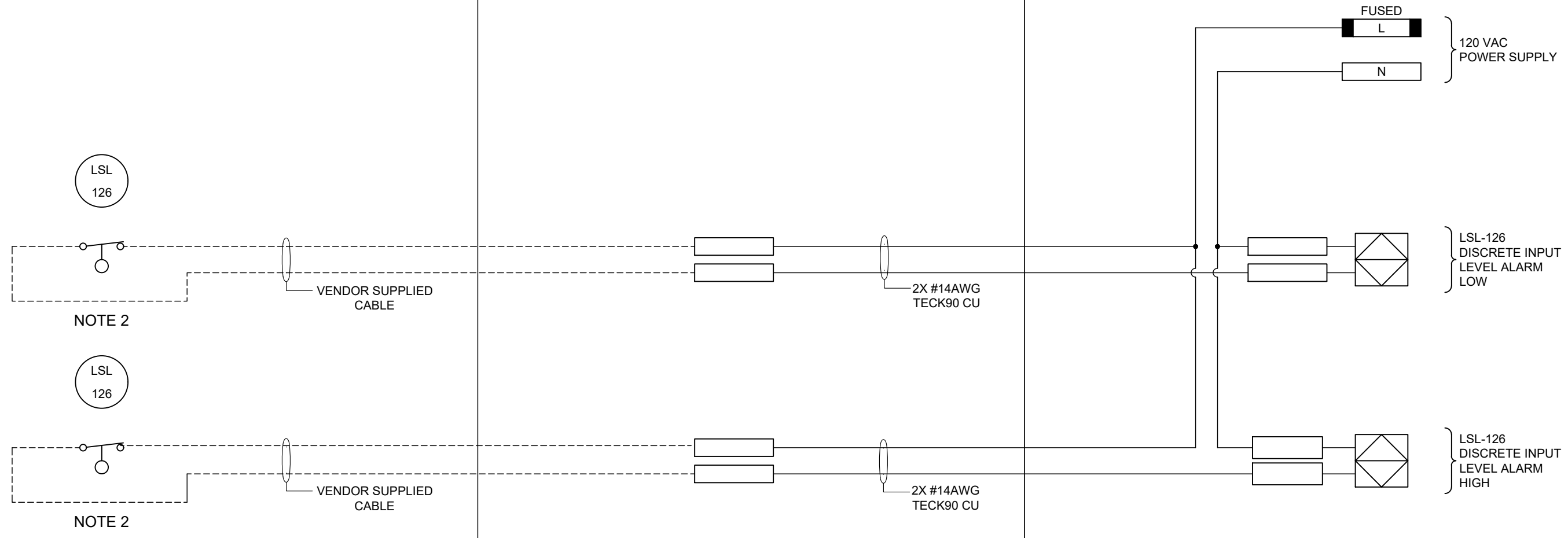
1-0601-AILD-A001

INSTRUMENT LOOP DIAGRAM

FIELD PROCESS AREA

FIELD JUNCTION BOX (NOTE 1)

MAIN CONTROL PANEL



LSL
126

LSL
126

NOTE 2

NOTE 2

VENDOR SUPPLIED
CABLE

VENDOR SUPPLIED
CABLE

2X #14AWG
TECK90 CU

2X #14AWG
TECK90 CU

FUSED
L
N

120 VAC
POWER SUPPLY

LSL-126
DISCRETE INPUT
LEVEL ALARM
LOW

LSL-126
DISCRETE INPUT
LEVEL ALARM
HIGH

NOTES

1. PROVIDE FIELD JUNCTION BOX AS REQUIRED.
2. CONNECT TO "NORMALLY CLOSED" CONTACTS FOR ALARMS AND "NORMALLY OPEN" CONTACTS FOR EQUIPMENT STATUS, ETC.

ISSUE/REVISION

I/R	DATE	DESCRIPTION
PA	2022.09.06	ISSUED FOR CONSTRUCTION

CONSULTANT

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PROJECT

CITY OF WINNIPEG,
DEACON FLOOD
PROTECTION UPGRADE

SHEET TITLE

INSTRUMENT LOOP DIAGRAM
TYPICAL WIRING DIAGRAM
DBPS LEVEL SWITCH HIGH AND LOW

SHEET NUMBER

1-0601-AILD-A002

CONTROL PANELS

1. GENERAL

1.1 Summary

- .1 All Control Panels shall be built by a CSA/cUL approved manufacturer and shall bear the CSA/cUL seal with the manufacturer's file number.
- .2 All new Control Panels shall be factory assembled and pre-wired. The Control Panel wiring shall be verified at the manufacturer's factory and completely tested before being shipped to the Site. Do not ship control panels until approval from the Contract Administrator is received.
- .3 Existing Control Panels that are substantially modified from the original installation shall have a new CSA/cUL seal applied.
- .4 Supply, install, wire and test all components inside the Control Panels according to the specifications herein and the Drawings.

1.2 References

- .1 Comply with latest edition of the codes and standards applicable and/or referenced in Division 26 and this Section.
- .2 The following is a list of standards which may be applicable in this Section:
 - .1 Canadian Standards Association (CSA):
 - .1 CSA C22.1, Canadian Electrical Code, Part I - Safety Standard for Electrical Installations.
 - .2 CSA C22.2 No. 14-13, Industrial control equipment.
 - .2 National Electrical Manufacturers Association (NEMA).
 - .3 City of Winnipeg
 - .1 Electrical Design Guide, latest revision
 - .2 Automation Design Guide, latest revision

1.3 Acronyms and Abbreviations

- .1 FAT: Factory Acceptance Test
- .2 PLC: Programmable Logic Controller
- .3 SIFT: System Integration Functional Test

1.4 Submittals

- .1 Submit Shop Drawings and product data in accordance with Specification E6
- .2 Shop Drawings:

CONTROL PANELS

- .1 Complete specifications, catalog cuts, and descriptive literature, which shall include make and model of all components.
 - .2 Control panel layout drawings.
 - .3 Complete bill of materials.
 - .4 Electrical schematic and wiring diagrams, interconnection diagram showing power and control interfaces among all control panel components. The diagrams are to be fully comprehensive so that every circuit loop can be followed completely.
 - .5 Configuration/parameter sheets including switch settings, parameter settings, and addresses. Show factory default settings and proposed settings.
 - .6 Diagram showing dip switches complete with proposed settings.
 - .7 Control panel support frame design drawings signed and stamped by a structural engineer registered in the province of Manitoba.
- .3 Prior to construction:
- .1 Submit stamped red-line mark-ups of any proposed control panel modifications. If significant modifications are proposed/required, AutoCAD drawings will be supplied to the Contractor for revision.
- .4 FAT and SIFT requirements:
- .1 Refer to Division 26 FAT and SIFT Procedures for submittal requirements.
- .5 Prior to shipment:
- .1 Submit electronic pictures of enclosure exterior and interior, including door interior. For enclosures that are similar, one set of photos for each type may be submitted.
 - .1 Pictures to be of sufficient resolution to read component labels.
 - .2 Submit as-built drawings. Minor changes may be made via red-line mark-ups. Significant changes shall be made via red-line mark-ups with the associated change submitted on separate AutoCAD drawings.

1.5 Inspection

- .1 A factory inspection of the control panels will be performed at the discretion of the Contract Administrator based upon the pre-shipment submittals.

2. PRODUCTS

2.1 General

- .1 Construction of the control panels is required in accordance with the supplied drawings.
- .2 Devices of each function shall be of the same type and manufacturer.

CONTROL PANELS

2.2 Enclosures – Surface Mount

- .1 Provide all required hardware and accessories for a complete installation.
- .2 Install lamacoids as per the control panel layout drawings, with stainless steel screws.
- .3 Minimum CSA/NEMA ratings are as follows:
 - .1 In areas where corrosive gases are present: NEMA 4X, or as indicated on the drawings.
 - .2 In outdoor areas where no corrosive gasses are present: NEMA 3R, or as indicated on the drawings.
- .4 All enclosure angles and cut-outs shall be free of dents, gouges or weld marks, and shall present a clean, smooth appearance.
- .5 No screws, fittings or other fastenings shall be used on external panel faces, which must be free of any marks, scratches or defaults.
- .6 Minimum Metal Thickness: 14 gauge.
- .7 The exterior of the control panel shall be painted ANSI 61 grey.
- .8 The interior of the control panel shall be painted gloss white.
- .9 Component mounting plates shall be three (3) mm thick steel and shall be painted with one (1) coat of primer and one (1) coat of white baked enamel.
- .10 Doors:
 - .1 All control panel doors shall be 900 mm (36 inches) wide maximum.
 - .2 All control panel doors shall open through 180 degrees without restriction.
 - .3 Provide door mount document pocket in each panel.
 - .4 Provide both exterior lockable door and interior door. Interior panel door latch shall be mechanically interlocked such that the panel is fully de-energized before interior live electrical components are exposed.
- .11 Gasket:
 - .1 Seamless foam-in-place gasket (UL component recognized) on all external components.
- .12 Manufacturers:
 - .1 Hoffman (nVent).
 - .2 Or approved equal.

CONTROL PANELS

2.3 Sump Control Panels

- .1 Supply simplex automatic pump control panel for the Lift Station to control submersible pumps specified in the mechanical specifications. The controller shall start and stop the pump at the respective pumping station and shall include a fifteen (15) second time delay between consecutive starts.
- .2 Controllers shall be housed in a heavy gauge steel weatherproof enclosure suitable for rigid frame mounting complete with lockable hinged cover with heavy duty lock, protective hinged lock cover and three (3) sets of keys.
- .3 The control panel shall have an interior hinged door plate with a hand-off-auto switch for the pump, elapsed runtime meter, pump fault module faceplates/indicators, indicating lights for panel power, pump run status, faults, and the buzzer silence button.
- .4 Control panel shall be complete with a beacon and buzzer for faults. Annunciation devices shall be suitable for operation outdoors in -40deg C to +40 deg C.
- .5 Outdoor panels shall have an adequately sized enclosure heater and insulation. Heater shall ensure that all components are kept within their operable temperature range when outdoor temperatures reach -40°C. Internal thermostat for triggering the heater shall be set to 10°C.
- .6 Pump control panels servicing equipment in the yard manholes shall be complete with intrinsically safe barriers and associated appurtenances to meet a complete, functional, and safe installation. Provide a descriptive system document for intrinsically safe systems as per the CEC.
- .7 Provide level regulators at the pumping station, as specified in Section 40 72 00.
- .8 Pump control panels shall perform the following functions:
 - .1 FS1 - stop pump on falling liquid level.
 - .2 FS2 - start pump on rising liquid level.
 - .3 FS3 – high level alarm.
 - .4 FS4 - Spare.
 - .5 Refer to Section 40 61 96, Process Control Descriptions for additional required functions.
- .9 Acceptable manufacturers:
 - .1 Manco Control Systems.
 - .2 Vesta Automation.
 - .3 Shreem Systems & Solutions.
 - .4 Celco.
 - .5 Indus Automation.

CONTROL PANELS

- .6 3 Phase Power Systems (T&T Power Group).
- .7 Eascan Automation.
- .8 Hund Automation.
- .9 Or approved equal.

2.4 Valve Control Station

- .1 Provide local control panel for valve control with remote controller for each valve as shown on the P&IDs.
- .2 Control panel shall be complete with:
 - .1 Door-mounted local/Remote switch for each valve
 - .2 Door-mounted open/Close Switch for each valve
 - .3 Door-mounted indicating LEDs for open and closed positions for each valve.
 - .4 Nema 3R enclosure.
 - .5 Controls and power cabling shall be separated by a barrier within the enclosure.

2.5 Power Source

- .1 Each power source must be protected by a CSA approved circuit breaker or fuse.
- .2 The location of each power source must be clearly shown.
- .3 Panels powered by more than one electrical source shall display on their door; "Caution: This panel is electrically powered by more than one source".

2.6 Components

- .1 Unless written approval for use of unapproved components is received from the Contract Administrator, all electrical materials (e.g., conduit, fittings, wireways, etc.) shall be CSA or cUL approved.
- .2 Rails (DIN Rails):
 - .1 Rails used must be DIN Rail style TS 35 mm, slotted.
 - .2 When used to mount terminals, rails shall be mounted on straight raisers (rail support / mounting feet) so as to raise them so that the top of the terminals are at the same height as the top of the adjacent wiring duct.
 - .3 Raisers (rail support / mounting feet) shall not be used when rail hosts heavy components.
- .3 Terminals:
 - .1 Quantity:

CONTROL PANELS

- .1 Accommodate present and spare indicated needs.
- .2 One (1) wire per terminal for field wires entering/exiting enclosures.
- .3 Maximum of two (2) wires on each side of a terminal for internal enclosure wiring.
- .4 Installed Spare Terminals: As shown on the Drawings.
- .2 General:
 - .1 Connection Type: Screw compression clamp.
- .3 Compression Clamp:
 - .1 Complies with DIN-VDE 0611.
 - .2 Hardened steel clamp with transversal grooves that penetrate wire strands providing a vibration-proof connection.
 - .3 Guides strands of wire into terminal.
- .4 Screws: Hardened steel, captive, and self-locking.
- .5 Current Bar: Copper or treated brass.
- .6 Insulation:
 - .1 Thermoplastic rated for minus 55 to plus 110°C.
 - .2 Two (2) funneled shaped inputs to facilitate wire entry.
- .7 Mounting:
 - .1 Standard DIN rail.
 - .2 Terminal block can be extracted from an assembly without displacing adjacent blocks.
 - .3 End Stops: Minimum of one (1) at each end of rail.
- .8 Jumpers: Allow jumper installation without loss of space on terminal or rail.
- .9 Marking System:
 - .1 Terminal number shown on both sides of terminal block.
 - .2 Markings must be machine printed. Hand written markings are not allowed.
 - .3 Terminal strip numbers shown on end stops.
 - .4 Mark terminal block and terminal strip numbers as shown on panel control diagrams and loop diagrams.

CONTROL PANELS

- .10 Terminal blocks shall be designed for the size of the wires to be connected to them. Terminal blocks used for analog, digital, and power cables shall be identified and physically separated from each other.
- .11 Drawings and templates supplied may not detail all hardware components such as labels, stoppers, rail lifters, end plates, separators, etc. The supplier must supply and install such components when required.
- .12 Loose Spare Requirements:
 - .1 Provide either thirty (30) or three (3) percent, whichever is less, of each type of terminal used on the Project.
- .13 Terminal Block Types:
 - .1 Control wiring – General:
 - .1 Connection type: Screw connection.
 - .2 Mounting: NS 35 mm DIN rail.
 - .3 Approval: CSA.
 - .2 Manufacturer and Series:
 - .1 Phoenix Contact UT 4 and UTTB 4 series.
 - .2 Or approved equal.
 - .3 Terminal Block, Feed-through:
 - .1 Rated Voltage: 600 V AC.
 - .2 Rated Current: 30 amp.
 - .3 Wire Size: 26 to 10 AWG.
 - .4 Color: Gray body.
 - .5 Width: 6.2 mm.
 - .6 Bridging: Plug-in bridge.
 - .7 Standard of acceptance: Phoenix Contact 3046184.
 - .4 Terminal Block, Feed-through:
 - .1 Rated Voltage: 600 V AC.
 - .2 Rated Current: 85 A.
 - .3 Wire Size: 14 to 4 AWG / 12 to 6 AWG flexible.
 - .4 Color: Gray body.

CONTROL PANELS

- .5 Width: 12.2 mm.
- .6 Bridging: Fixed Bridge.
- .7 Standard of acceptance: Phoenix Contact 3006043 (UK 16 N).
- .5 Terminal Block, Ground:
 - .1 Wire Size: 26 to 10 AWG.
 - .2 Color: Green and yellow body.
 - .3 Width: 6.2 mm.
 - .4 Grounding: Electrically grounded to mounting rail.
 - .5 Standard of acceptance: Phoenix Contact 3046207.
- .6 Terminal Block, Knife Disconnect:
 - .1 Rated Voltage: 600 V AC.
 - .2 Rated Current: 16 A.
 - .3 Wire Size: 26 to 10 AWG.
 - .4 Color: Gray body, orange switch.
 - .5 Width: 6.2 mm.
 - .6 Bridging: Plug-in bridge.
 - .7 Standard of acceptance: Phoenix Contact 3046139.
- .7 Terminal Block, Fused:
 - .1 Rated Voltage: 600 V AC.
 - .2 Rated Current: 6.3 A.
 - .3 Wire Size: 26 to 10 AWG.
 - .4 Color: Gray body.
 - .5 Width: 6.2 mm.
 - .6 Bridging: Plug-in bridge.
 - .7 Fuse: 5 mm x 20 mm.
 - .8 Standard of acceptance: Phoenix Contact 3046142, 3036806.
- .8 Terminal Block, Fused:

CONTROL PANELS

- .1 Rated Voltage: 300 V AC.
- .2 Rated Current: 10 A.
- .3 Wire Size: 20 to 6 AWG.
- .4 Color: Gray body.
- .5 Width: 12 mm.
- .6 Bridging: Fixed Bridge.
- .7 Fuse: 6.3 mm x 32 mm.
- .8 Standard of acceptance: Phoenix Contact 3005507.
- .9 Terminal Block, Double Level, Fused:
 - .1 Rated Voltage: 500 V AC.
 - .2 Rated Current: 6.3 A.
 - .3 Wire Size: 26 to 10 AWG.
 - .4 Color: Gray.
 - .5 Width: 6.2 mm.
 - .6 Bridging: Plug-in bridge.
 - .7 Fuse: 5 mm x 20 mm.
 - .8 Standard of acceptance: Phoenix Contact 3044720, 3036806.
- .10 Power wiring over 6.3 A
 - .1 Connection type: Screw connection.
 - .2 Mounting: NS 35 mm DIN rail.
 - .3 Approval: CSA.
- .11 Manufacturer and Series:
 - .1 Phoenix Contact UK 10/16 series.
 - .2 Or approved equal.
- .4 Electronic Circuit Protector – Class 2 current limiting:
 - .1 Electronic Circuit Protectors for disconnection of 24 VDC loads as per control panel layout drawings.
 - .2 Requirements:

CONTROL PANELS

- .1 Overload disconnection.
- .2 Active current limitation.
- .3 Manual On/Off button.
- .4 Current rating: As required.
- .5 Approvals: CSA.
- .6 DIN rail mounting.
- .3 Manufacturer and Model:
 - .1 Weidmuller, ESX10-T series.
- .5 Ground Bus Bar:
 - .1 Supply a ground bus bar in each control panel. Supply an isolated ground bus bar where shown on the Drawings.
 - .2 Requirements:
 - .1 Tapped holes with screws.
 - .2 Bar to have sufficient connection points for all cables entering the control panel, plus 25 percent spare.
 - .3 Maximum one wire termination per screw.
 - .4 Manufacturer and Model: ILSCO D167 series.
 - .5 Or approved equal.
- .6 Pushbutton, Non-Illuminated:
 - .1 General:
 - .1 Function: Initiate discrete control functions.
 - .2 Type: 30 mm, heavy-duty, oiltight, industrial, momentary contact.
 - .3 Approvals: CSA.
 - .2 Mounting:
 - .1 Panel cut out: 30.6 mm single round hole.
 - .2 Panel thickness: 1.59 mm to 4.76 mm.
 - .3 Pushbutton Features:
 - .1 Operator: Pushbutton, flush or extended head as noted.

CONTROL PANELS

- .2 Cap colour: Black, unless otherwise noted.
- .3 Cap text: None, unless otherwise noted.
- .4 Boot: None, unless otherwise noted.
- .4 Legend Plate:
 - .1 Standard size (46.4 H x 45.2 W, mm), unless otherwise noted.
 - .2 Text: As noted or shown.
 - .3 Material:
 - .1 Non-corrosive environment: Aluminum.
 - .2 Corrosive environment: Plastic.
- .7 Signal Interface:
 - .1 Contact Block:
 - .1 Type: Silver-coated butting, unless otherwise noted.
 - .2 Rating: 10 amps continuous at 120 VAC or as noted.
 - .3 Sequence: Break-before-make, unless otherwise shown.
 - .4 Arrangement: Normally open or normally closed as shown, or perform functions noted.
 - .5 Electrical design life: 1,000,000 cycles.
 - .6 Terminals: Screw with strap clamp, unless otherwise noted.
- .8 Manual small motor switches:
 - .1 Manufacturers:
 - .1 Schneider Type K or SK.
 - .2 Or approved equal.
- .9 Pushbutton, Emergency Stop:
 - .1 General:
 - .1 Function: Initiate shutdown of equipment.
 - .2 Type: 30 mm, heavy-duty, oiltight, industrial, push-pull, maintained position.
 - .2 Mounting:
 - .1 Panel cut-out: 30.6 mm single round hole.

CONTROL PANELS

- .2 Panel thickness: 1.59 mm to 4.76 mm.
- .3 Pushbutton Features:
 - .1 Operator: Pushbutton, mushroom head.
 - .2 Cap colour: Red.
 - .3 Text: None.
 - .4 Illumination: None.
 - .5 Boot: None, unless otherwise noted.
- .4 Legend Plate:
 - .1 Standard size (46.4 H x 45.2 W, mm), unless otherwise noted.
 - .2 Text: As noted or shown.
 - .3 Material:
 - .1 Non-corrosive environment: Aluminum.
 - .2 Corrosive environment: Plastic.
- .5 Signal Interface:
 - .1 Contact Block:
 - .1 Type: Silver-coated butting, unless otherwise noted.
 - .2 Rating: 10 amps continuous at 120 VAC or as noted.
 - .3 Sequence: Break-before-make, unless otherwise shown.
 - .4 Arrangement: Normally open or normally closed as shown, or perform functions noted.
 - .5 Electrical design life: 1,000,000 cycles.
 - .6 Terminals: Screw with strap clamp, unless otherwise noted.
- .10 Pilot Light:
 - .1 General:
 - .1 Function: Display discrete control functions.
 - .2 Type: 30 mm, heavy-duty, oiltight, industrial.
 - .3 Approvals: CSA.
 - .2 Mounting:

CONTROL PANELS

- .1 Panel cut-out: 30.6 mm single round hole.
- .2 Panel thickness: 1.59 mm to 4.76 mm.
- .3 Light Features:
 - .1 Lights: LED, unless otherwise noted.
 - .2 Voltage: As noted.
 - .3 Lens Color: As noted.
- .4 Legend Plate:
 - .1 Standard size (46.4 H x 45.2 W, mm), unless otherwise noted.
 - .2 Text: As noted or shown.
 - .3 Material:
 - .1 Non-corrosive environment: Aluminum.
 - .2 Corrosive environment: Plastic.
- .5 Signal Interface:
 - .1 Terminals: Screw with strap clamp, unless otherwise noted.
- .11 Pilot Light, Push-to-Test:
 - .1 Function:
 - .1 Push to test light, display discrete control functions; or
 - .2 Initiate and display discrete control functions.
 - .3 Type: 30 mm, heavy-duty, oiltight, industrial, momentary contact.
 - .4 Approvals: CSA.
 - .2 Mounting:
 - .1 Panel cut-out: 30.6 mm single round hole.
 - .2 Panel thickness: 1.59 mm to 4.76 mm.
 - .3 Light Features:
 - .1 Lights: LED, unless otherwise noted.
 - .2 Voltage: As noted.
 - .3 Lens Color: As noted.

CONTROL PANELS

- .4 Pushbutton Features:
 - .1 Operator: Pushbutton.
 - .2 Boot: None, unless otherwise noted.
- .5 Legend Plate:
 - .1 Standard size (46.4 H x 45.2 W, mm), unless otherwise noted.
 - .2 Text: As noted or shown.
 - .3 Material:
 - .1 Non-corrosive environment: Aluminum.
 - .2 Corrosive environment: Plastic.
- .6 Signal Interface:
 - .1 Contact Block:
 - .1 Type: Silver-coated butting, unless otherwise noted.
 - .2 Rating: 10 A continuous at 120 VAC or as noted.
 - .3 Sequence: Break-before-make, unless otherwise shown.
 - .4 Arrangement: Normally open or normally closed as shown, or perform functions noted.
 - .5 Electrical design life: 1,000,000 cycles.
 - .6 Terminals: Screw with strap clamp, unless otherwise noted.
- .12 Selector Switch:
 - .1 General:
 - .1 Function: Select discrete control functions.
 - .2 Type: 30 mm, heavy-duty, oiltight, industrial, maintained contact.
 - .3 Approvals: CSA.
 - .2 Mounting:
 - .1 Panel cut-out: 30.6 mm single round hole.
 - .2 Panel thickness: 1.59 mm to 4.76 mm.
 - .3 Switch Features:
 - .1 Operator: Black non-illuminated lever on switch, unless otherwise noted.

CONTROL PANELS

- .2 Boot: None, unless otherwise noted.
- .3 Positive indexing with stops to limit travel to the number of positions shown.
- .4 Legend Plate:
 - .1 Standard size (46.4 H x 45.2 W, mm), unless otherwise noted.
 - .2 Text: As noted or shown.
 - .3 Material:
 - .1 Non-corrosive environment: Aluminum.
 - .2 Corrosive environment: Plastic.
- .5 Signal Interface:
 - .1 Contact Block:
 - .1 Type: Silver-coated butting, unless otherwise noted.
 - .2 Rating: 10 amps continuous at 120 VAC or as noted.
 - .3 Sequence: Break-before-make, unless otherwise shown.
 - .4 Arrangement: Normally open or normally closed contact(s) as shown, or perform functions noted.
 - .5 Electrical design life: 1,000,000 cycles.
 - .6 Terminals: Screw with strap clamp, unless otherwise noted.
- .13 Potentiometer:
 - .1 General:
 - .1 Function: Adjustable analog setpoint.
 - .2 Type: Heavy-duty, industrial, oiltight.
 - .2 Performance:
 - .1 Resistance: 1000 ohms, unless otherwise noted.
 - .2 Temperature, operating: 0 to 55°C.
 - .3 Humidity, operating: 50 percent at 40°C.
 - .4 Mechanical design life: 25,000 cycles.
 - .5 Rated for 300 V AC maximum.
 - .3 Mounting:

CONTROL PANELS

- .1 30.6 mm single round hole.
- .2 Panel thickness:
 - .1 1.59 to 4.76 mm.
 - .2 Counterboring required for thicknesses greater than 4.76 mm.
- .4 Legend Plate:
 - .1 Standard size (46.4 H x 45.2 W, mm), unless otherwise noted.
 - .2 Scale: 0 to 100 percent, unless otherwise noted.
 - .3 Legend: As noted or shown.
 - .4 Material:
 - .1 Non-corrosive environment: Aluminum
 - .2 Corrosive environment: Plastic
 - .5 Signal interface: Three-wire.
- .14 Pilot Device Colours
 - .1 The following pilot device colours shall be used:

.1 Running Status Light:	Green
.2 Stopped Status Light:	Blue
.3 Position Open Status Light:	Green
.4 Position Closed Status Light:	Blue
.5 Alarm Status Light – Major or Safety:	Red
.6 Warning or Minor Alarm Status Light:	Amber
.7 Ready Status Light:	Blue
.8 Operating Mode – Normal Mode:	Blue
.9 Operating Mode – Alternate Mode:	Amber
.10 Start Pushbutton:	Green or Black
.11 Stop Pushbutton:	Red or Black
.12 Test Pushbutton:	Black
.13 Reset Pushbutton:	Black

CONTROL PANELS

- .14 E-Stop Pushbutton: Red push-pull with mushroom
- .15 Overload Reset Pushbutton: Blue with White "R"
- .16 Selector Switch: Black with White Insert
- .15 Relays – General Purpose Miniature industrial relays:
 - .1 General:
 - .1 Approvals: CSA
 - .2 Coil voltage: As Noted.
 - .3 Relay Mounting: plug-in type socket.
 - .4 Socket type: Screw terminal.
 - .5 Socket mounting: 35 mm DIN rail.
 - .2 Control Circuit Switching Relay:
 - .1 Type: Compact general purpose plug-in.
 - .2 Contact Arrangement: As noted.
 - .3 Contact Rating: As noted or shown.
 - .4 Contact material: Silver tin oxide alloy.
 - .5 Coil voltage: As noted or shown.
 - .6 Coil operating voltage display: LED.
 - .7 Operation temperature: -40 to 70°C.
 - .8 Expected mechanical life: 10,000,000 cycles.
 - .3 Manufacturer and Series:
 - .1 Finder 46 Series.
 - .2 Or approved equal in accordance with B8.
- .16 Relays – I/O:
 - .1 General:
 - .1 Approvals: CSA.
 - .2 Relay Mounting: plug-in type socket.
 - .3 Socket type: Screw terminal.

CONTROL PANELS

- .4 Socket mounting: 35 mm DIN rail.
- .2 Control Circuit Switching Relay:
 - .1 Type: Compact general purpose plug-in.
 - .2 Contact Arrangement: As noted.
 - .3 Contact Rating: As noted or shown.
 - .4 Coil voltage: As noted or shown.
 - .5 Coil operating voltage display: LED.
 - .6 Operation temperature: -40 to 55°C.
 - .7 Expected mechanical life: 20,000,000 cycles.
- .3 Manufacturer and Series:
 - .1 Phoenix Contact PLC-RSC Series.
 - .2 Or approved equal.
- .4 Standard of Acceptance:
 - .1 Relay interface for PLC Discrete Inputs, SPDT:
 - .1 Coil rating: 3.5 mA at 120 VAC.
 - .2 Contact material: Gold-plated silver tin oxide alloy.
 - .3 Contact switching voltage: 36 V DC max.
 - .4 Contact minimum switching current: 1 mA.
 - .5 Contact maximum inrush current: 50 mA.
 - .6 Wire Size: 26 to 14 AWG for both input and output side.
 - .7 Color: Gray body.
 - .8 Width: 6.2 mm.
 - .9 Bridging: Plug-in bridge.
 - .10 Approvals: cULus.
 - .11 Standard of acceptance: Phoenix Contact 2966281.
 - .2 Relay interface for PLC Discrete Outputs, SPDT: Coil rating: 9 mA at 24V dc.
 - .1 Contact material: Silver tin oxide alloy.

CONTROL PANELS

- .2 Contact switching voltage: 5 V AC min, 250 V ac max.
- .3 Contact limiting continuous current: 6A.
- .4 Wire Size: 26 to 14 AWG for both input and output side.
- .5 Color: Gray body.
- .6 Width: 6.2 mm.
- .7 Bridging: Plug-in bridge.
- .8 Approvals: cULus.
- .9 Standard of acceptance: Phoenix Contact 2966171.
- .3 Relay interface between PLCs, SPDT:
 - .1 Coil rating: 11 mA at 24 V AC/DC.
 - .2 Contact material: Gold-plated silver tin oxide alloy.
 - .3 Contact switching voltage: 36 V DC max.
 - .4 Contact minimum switching current: 1 mA.
 - .5 Contact maximum inrush current: 50 mA.
 - .6 Wire Size: 26 to 14 AWG for both input and output side.
 - .7 Color: Gray body.
 - .8 Width: 6.2 mm.
 - .9 Bridging: Plug-in bridge.
 - .10 Approvals: cULus
 - .11 Standard of acceptance: Phoenix Contact 2966278.
- .17 Relays –Motor Starting and Solenoids:
 - .1 Approvals: CSA.
 - .2 Coil voltage: As per the drawings.
 - .3 Relay Mounting: Plug-in type socket.
 - .4 Socket Type: Screw terminal interface with wiring.
 - .5 Socket Mounting: Rail.
 - .6 Furnish hold-down clips.

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- .7 Control Circuit Switching Relay:
 - .1 Type: Compact general purpose plug-in.
 - .2 Contact Arrangement: As noted.
 - .3 Contact Rating: 16A.
 - .4 Contact single phase motor rating: 1/3 Hp at 120 VAC.
 - .5 Contact Dielectric Strength: 1000 VAC.
 - .6 Contact Material: Silver cadmium oxide alloy.
 - .7 Coil Voltage: As noted or shown.
 - .8 Coil Power: 0.5 watts (dc), 1.2 VA (AC).
 - .9 Expected Mechanical Life: 10,000,000.
 - .10 Indication Type: LED indicator lamp.
 - .11 Ambient temperature: -40 to 70°C.
- .8 Manufacturer:
 - .1 Finder 48.61 Series.
 - .2 Or approved equal.
- .18 Analog Signal Isolators:
 - .1 Provide galvanic isolation between analog signals where not already provided by the programmable logic controller or other components.
 - .2 Input: 0-5V, 1-5V, 0-10V, and 4-20 mA (switch selectable).
 - .3 Output: 4-20 mA.
 - .4 Channels per isolator: 2 or 4.
 - .5 DC input resistance:
 - .1 Current inputs: 50 Ω .
 - .2 Voltage inputs: 1 M Ω .
 - .6 Performance:
 - .1 Output ripple: < 10 mV peak-to-peak measured across a 250 Ω resistor.
 - .2 Isolation: 1000V rms input-to-output and channel-to-channel.
 - .3 Common mode rejection: > 95dB @ 60 Hz, 500V rms maximum.

CONTROL PANELS

- .7 Features:
 - .1 Adjustable zero and span for each channel via potentiometers.
 - .2 Removable wiring connectors.
- .8 Environmental:
 - .1 Temperature range, operating: -40 to 70°C.
 - .2 Relative humidity, operating: 0-95 percent non-condensing.
 - .3 Ambient temperature effect: plus or minus 0.015 percent of span/°C maximum.
- .9 Manufacturers:
 - .1 Acromag.
 - .2 Moore Industries.
 - .3 MTL Instruments.
 - .4 Phoenix Contact.
- .19 Intrinsic Safety Barriers:
 - .1 Monitor discrete signals that originate in hazardous area and are used in a safe area.
 - .2 Interface analog signals as they pass from hazardous area to safe area.
 - .3 Isolation Method: Galvanic Isolation.
 - .4 Approvals: CSA or cUL
 - .5 Manufacturers:
 - .1 Phoenix Contact.
 - .2 Pepperl+Fuchs.
 - .3 MTL Instruments.
- .20 Wiring Interface: Terminate and identify wiring entering or leaving enclosures.
 - .1 Analog and Discrete Signal Wires: Terminate at numbered terminal blocks as shown on the wiring diagrams.
 - .2 Wiring for Special Signals: Terminate communications, digital data, and multiplexed signals using manufacturer's standard connectors for the device to which the signals terminate.
- .21 Wiring:
 - .1 All analog signal wiring shall be 18 AWG shielded twisted pair.

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- .1 Shield wires exiting the jacket must be covered with a black heat shrink, and the overall cable at the jacket end must also be covered with a heat shrink.
- .2 Standard of Acceptance:
 - .1 Belden No. 8760.
- .2 All 24 VDC discrete signal panel wiring shall be 16 AWG TEW/MTW stranded conductor with 300V, 105°C insulation.
- .3 All 120 VAC discrete signal panel wiring shall be 14 AWG TEW/MTW stranded conductor with 300V, 105°C insulation.
- .4 All 24 VDC and 120 VAC power wiring shall be 12 AWG minimum unless shown otherwise.
- .5 The sizes and colours of wires shall be in accordance with the CSA and the Canadian Electrical Code, and Wire Colour Coding.
- .6 Provide wire barrel ferules where possible.
- .7 Ethernet Patch Cords:
 - .1 Requirements:
 - .1 Cat-6, shielded twisted pair.
- .22 Wiring Duct:
 - .1 All wires shall be run in narrow slot wiring duct, unless shown otherwise.
 - .2 Wiring Duct shall be installed on both sides of the panel and between the DIN rails as per the drawings.
 - .3 Wire or cable, connected to internal device or arriving from external device, shall be uncovered by Wiring Duct for a maximum of 10 cm or as required by its minimum bending radius.
 - .4 120 VAC wires cannot share wiring duct with 12 VDC, 24 VDC or 4-20 mA wires, but may cross their path.
 - .5 All DC, AC, and communication wiring shall be routed in separate wireways to prevent signal interference. 24 VDC Class 2 circuits and communication wiring may share the same wiring duct.
 - .6 Wire ties shall be non-metallic.
 - .7 Where the voltage level and/or type of signal is shown on the drawings, provide an adhesive label to the cover of the wiring duct with this information.
 - .8 Manufacturer:
 - .1 Panduit.

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- .2 Or approved equal.
- .9 Wire Identification: Numbered and tagged at each termination.
 - .1 Wire Tags: Machine printed, heat shrink.
 - .2 Standard of Acceptance:
 - .1 Brady PermaSleeve.
 - .2 Tyco Electronics.
- .23 Wire Color Coding:
 - .1 Utilize the following wire colours for the types of voltage/signals indicated:

.1	120 VAC Line:	Black
.2	120 VAC Control:	Red
.3	120 VAC Neutral:	White
.4	24 VDC Supply:	Blue
.5	24 VDC Control:	Blue
.6	24 VDC Common:	Brown
.7	4-20 mA Signal:	White (+), Black (-)
.8	Protective Earth	Green
.9	Signal Ground:	Green/Yellow
.10	Profibus:	Red/Green
- .24 Overcurrent Protection:
 - .1 Panel-mounted devices and all control circuits shall be protected by appropriately sized fuses or circuit breakers.
- .25 Control Power Transformer:
 - .1 Function: Provide required secondary voltage level with high degree of stability.
 - .2 Type: Single phase, indoor, industrial.
 - .3 Ratings:
 - .1 Power Rating: As shown on the drawings.
 - .2 Primary voltage: 600 VAC.
 - .3 Secondary voltage: 120 VAC.

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- .4 Frequency: 60 Hz.
- .5 Temperature rise 55°C, insulation class 105°C
- .4 Mounting: Directly to enclosure back panel with mounting feet made of heavy steel and welded or bolted to the core.
- .5 Standard secondary and optional primary fuse kits.
- .6 With Finger Guards.
- .7 Approvals: cULus.
- .8 Manufacturer and model:
 - .1 Hammond PH100PG, FG2.
 - .2 Or approved equal.
- .26 Power Supplies and Redundancy Modules (24 VDC):
 - .1 Approvals: CSA.
 - .2 Type: Regulated switch mode.
 - .3 Watt Rating: As noted.
 - .4 Input: 100-240 V AC, 45-65 Hz.
 - .5 Output: 24 V DC.
 - .6 Mounting: NS 35 DIN rail.
 - .7 Capable of redundant operation with redundancy module.
 - .8 Redundancy module:
 - .1 MOSFET based.
 - .2 Adjustable output voltage.
 - .3 Loss of redundancy alarm LED and contact.
 - .4 Power fail alarm contact.
 - .9 Performance:
 - .1 Load regulation: < 2 percent.
 - .10 Temperature derating: 2.5 percent/°C from 60°C.
 - .11 Output ripple: < 30 mV peak-to-peak.
 - .12 Efficiency: 93 percent or greater.

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- .1 Features:
 - .1 Capable of parallel operation.
 - .2 Power boost: 130 percent handle start-up loads and temperature derating effect.
 - .3 Input transient surge protection.
 - .4 Input overcurrent protection.
 - .5 Output overcurrent protection.
- .2 Status lights:
 - .1 DC OK LED: active, green.
 - .2 Alarm LED: red.
 - .3 Power boost LED: power boost active, yellow.
- .13 Status contacts:
 - .1 Power supply failure, qty 1 normally open (Form A), contact closed during normal operation.
- .14 Environmental:
 - .1 Temperature, operating: -25 to 60°C.
 - .2 Humidity, operating: max 95 percent, non-condensing.
 - .3 Manufacturer and series:
 - .1 Phoenix Contact, Quint Series.
 - .2 Or approved equal.
- .27 Internal Lighting:
 - .1 All control panels of a depth greater than or equal to twelve (12) inches shall be equipped with a lighting device with a door switch. Whenever the door is opened, the lighting system shall automatically be activated.
 - .2 Fixture mounting: top-centre of enclosure, unless otherwise noted.
 - .3 Lights: LED, white.
 - .4 Power supply: 120VAC.
 - .5 Manufacturer:
 - .1 Hoffman (nVent),

CONTROL PANELS

- .2 Hammond,
- .3 Or approved equal.

.28 Cooling and Heating Systems

- .1 Control panels shall be designed for the environmental conditions of the installation location. Cooling and heating systems shall be in accordance with the specific NEMA rating required by NEMA ICS 6 and NEMA 250.

.29 CSA/NEMA Rating:

- .1 All components mounted into the enclosure wall, or to the enclosure shall be rated equal or greater than the CSA/NEMA rating of the enclosure. All wall penetrations shall be sealed to maintain the CSA/NEMA rating of the enclosure.

2.7 Spare Components

- .1 Provide the following in a clear plastic bag attached to the panel door interior of each panel:
 - .1 Two (2) spares of each fuse type and rating.
 - .2 One (1) spare of each Electronic Circuit Protector – Class 2 rating, as applicable.
 - .3 One (1) spare of each type of door mounted pilot device.

3. EXECUTION

3.1 General

- .1 Construct control panels in accordance with CSA C22.2 No. 14.

3.2 Wiring

- .1 Panel wiring shall be installed in a neat and orderly manner.
- .2 All conductors shall be securely fastened to terminals at both ends; no splices are allowed inside the panel.
- .3 No more than two (2) conductors may be terminated under each terminal screw. All internal panel conductors shall be connected to the same side of a terminal block, and external conductors to the other side. The only exception is for fused terminals which require connection to the field side for internal wiring.
- .4 All wires and cables inside the control panels shall be identified on both ends using nonerasable labels.
- .5 Identification shall follow the supplied documents, such as wiring diagrams.
 - .1 Label both ends of each wire.
 - .2 Utilize machine printed non-slip labels. Wrap-around or self-adhesive markers shall not be permitted.

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- .3 Wherever possible wire labels shall be positioned to be read from the panel opening without removal of wire duct covers or other wiring.
- .6 Individual conductors or wires exiting a cable shall be identified using non-erasable labels.
- .7 The routing of all analog, digital, and power cable wiring inside control panels shall be segregated as much as possible, in distinct wiring ducts, by the type of signal they are carrying. All wires shall be physically protected by wiring ducts with covers. The wiring ducts shall be of sufficient size to be filled to a maximum of 40 percent when all wires are inside.
- .8 Group and form wiring into a loop when going from a fixed part of the panel to a door such that there is sufficient slack to minimize strand fatigue and breaking. Secure at each end so that bending or twisting will be around longitudinal axis of wire. Protect bend area with sleeve.
- .9 Provide abrasion protection for wire bundles that pass through holes or across edges of sheet metal.
- .10 Connections to Screw Type Terminals:
 - .1 Locking-fork-tongue or ring-tongue lugs.
 - .2 Use manufacturer's recommended tool with required sized anvil to make crimp lug terminations.
 - .3 Wires terminated in a crimp lug, maximum of one.
 - .4 Lugs installed on a screw terminal, maximum of two (2).
- .11 Connections to Compression Clamp Type Terminals:
 - .1 Strip, prepare, and install wires in accordance with terminal manufacturer's recommendations.
 - .2 Wires installed in a compression screw and clamp, maximum of one for field wires entering enclosure, otherwise maximum of two (2).
- .12 The wiring arrangement shall not interfere with access to panel-mounted devices or spaces for future equipment.
- .13 Arrange wiring to allow access for testing, removal, and maintenance of circuits and components.
- .14 Locate entry points of cables to control panel to allow for wiring duct designations to be utilized as shown on panel layout drawings.

3.3 Grounding

- .1 All control panel components shall be adequately grounded in accordance with the component manufacturer's instructions, especially control system components.
- .2 Firmly bond all panel mounted devices on or within the panels to ground. Provide supplementary bonding conductors for back panels and doors. Attach a separate bonding conductor to all devices that are not firmly fastened to the panels with screws for such devices as case mounted instruments, meters, etc.

CONTROL PANELS

- .3 Where ground bars are installed on to the rear or side wall of the enclosure, seal screw penetrations to maintain enclosure rating.
- .4 Ground terminal block rails to ground bus.

3.4 Component Installation

- .1 Components on the front of the panel shall be identified with an individual permanent nameplate installed in an organized manner. The nameplate must identify the component's function.
- .2 Install acorn nuts and rubber washers on all machine screws that protrude out of the panel.
- .3 Each component inside the control panel shall be identified with a nameplate corresponding to the drawings. Identification nameplates for relays shall be installed on the enclosure back panel rather than the pluggable relay.
- .4 All non-DIN rail mountable devices in the control panel shall be mechanically affixed to the back panel with either tapped or self-tapping screws.
- .5 All control devices shall be mounted so that any component can be replaced without removing the sub-panel or other components.
- .6 Components and/or auxiliary instruments mounted at the rear of the panel shall be readily accessible and their installation shall not be affected by, or interfere with the removal of any panel instrument.
- .7 Nameplates shall be made of lamacoid material with a white background and engraved black letters for internal and external components. Nameplates must resist harsh industrial conditions. Fasten lamacoids using stainless steel self-tapping screws. Supply and install all required fuses.
- .8 Control devices must be spaced adequately to allow for cooling, replacement, servicing, and wiring access.
- .9 Control devices shall be grouped according to voltage and function to reduce electrical noise.
- .10 Cut-outs for instruments shall be within the tolerances specified by the instrument manufacturer.
- .11 If cut-outs are specified for future instruments, the cut-outs shall be covered by removable steel plates 3 mm (1/8 inch) thick. The cover plates shall be finished and painted with the same paint as applied to the front panel.
- .12 If any panel-mounted item is not available for installation before the panel is scheduled for shipment, wiring from the terminal block to the panel location for the item shall be completed, wire ends shall be formed exactly to the configurations required, and identifying sleeves shall be applied, ready for connection.
- .13 Panel areas designated for future equipment shall be kept clear of stiffening members, rear mounted equipment, wiring, and all other interferences.
- .14 Ample space shall be provided for the entrance of external cables into the panel and for routing the cables to terminating points within the panel.

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.15 Jumper bars shall be used instead of jumpers where possible.

.1 Hinge Wiring: Secure at each end so that bending or twisting will be around longitudinal axis of wire. Protect bend area with sleeve.

.16 Provide manufacturer-recommended clearances around heat-generating components such as 24V dc power supplies and programmable logic controllers.

3.5 Identification

.1 Perform terminal identification using a computerized device. Handwriting is not acceptable.

.2 Label terminals as shown on Drawings.

.3 Install label above each terminal block with terminal block name.

3.6 Testing

.1 Testing of the control panels shall be completed to the greatest extent possible prior to the FAT, and shall include at minimum:

.1 Provide a signed and dated inspection sheet with all tests performed listed on it.

.2 The list of the various test procedures described hereunder is not restrictive, and does not relieve the control panel manufacturer of his responsibility to perform any other work that is not mentioned but requested to verify the good operation of the control panels.

.3 Isolate all instruments and components of the control panels as required to protect them from any damage during tests.

.4 Provide the services of qualified personnel as well as tools and equipment required to perform all tests and inspection of the control panels.

.5 Tests to include:

.1 Power supply functionality.

.2 PLC component functionality.

.3 Point to point tests of all inputs and outputs.

.4 Power terminal voltage verification.

.5 Relays and switches functionality.

.6 E-stop system component functionality.

.7 Receptacle and lighting functionality.

.8 Ethernet switch and fibre transceiver functionality.

.9 Profibus and Modbus gateways, Profibus DP/PA link couplers, and associated components functionality.

CONTROL PANELS

.6 If the panel is modified after tests have been performed, tests shall be repeated.

3.7 Shipment

- .1 If any panel-mounted item is not available for installation before the panel is scheduled for shipment, wiring from the terminal block to the panel location for the item shall be completed, wire ends shall be formed exactly to the configurations required, and identifying sleeves shall be applied, ready for connection.
- .2 Shipment of any panel having shortages of equipment shall be approved in writing by the Contract Administrator.
- .3 Transportation method to Site shall be in an air ride van or equivalent.

END OF SECTION