PART 1. GENERAL

1.01 DESCRIPTION

A. This section specifies the testing requirements for the electrical Work.

B. Conduct and pay for all tests.

C. Carry out tests in the presence of Contract Administrator. Provide instruments, meters, equipment and personnel required to conduct tests Performance Verification and prior to Total Performance.

D. Unless otherwise specified, testing requirements apply to all electrical systems including:

1. Power distribution system and grounding system.
2. Lighting and its control.
3. Motors, heaters and associated control equipment.
4. Communications systems.
5. Cable systems.

1.02 SUBMITTALS

A. Submit the following:

1. Details of test procedures and listing of test instruments prior to proceeding.
2. Recommended periodic on-going testing requirements.
3. Furnish manufacturer's certificate or letter confirming that entire installation as it pertains to each system has been installed to manufacturer's instructions.
4. Copies of production test records for production tests required by EEMAC and CSA standards for manufactured electrical equipment.
5. Provide operation and maintenance data for incorporation into manual.
6. Provide a collated, complete set of test records for each item of electrical equipment and interconnecting wiring.

PART 2. PRODUCTS (NOT USED)

PART 3. EXECUTION

3.01 READINESS FOR TESTING AND GENERAL REQUIREMENTS

A. Prior to energization of any equipment and commencement of tests, visually check and verify that the following has been completed:

1. The entire assembly is clean inside and outside. The cables are not lying loosely or hanging free.
2. The equipment is adequately bonded and grounded with the ground wires installed clear of bus Work.
3. The phasing of all bus Work and primary circuits is identified.
4. All equipment is correctly identified (front and back, if applicable).

5. Each starter is identified with correct drive number and drive title.
6. All cables leaving electrical equipment have proper cable connectors, and are properly identified.
7. All unused holes are adequately plugged.
8. All unused wall and floor openings are sealed.
9. Relay and metering sections of equipment enclosures are properly identified.
10. Motors and connected units have been properly secured to the base, and aligned.
11. Equipment nameplate data corresponds with characteristics of power supply.
12. A single line diagram for the primary supply and feeder system is available in all electrical rooms.
13. Emergency or stand-by lighting system is operational.
14. The installation is in a safe condition, there are no unguarded live parts. Conduit seals are in place if a hazardous condition could occur during the testing phase.

3.02 PREFUNCTIONAL CHECKOUT

A. Prior to functional testing, adjust and make operational all protective devices. Prior to energization of equipment, perform a functional checkout of the control circuit consisting of energizing each control circuit and operating each control, alarm or malfunction device and each interlock in turn to verify that the specified action occurs. Submit a description of the proposed functional test procedures prior to the performance of functional checkout.

B. Verify that motors are connected to rotate in the correct direction. Verification may be accomplished by momentarily energizing the motor, provided the Contractor confirms that neither the motor nor the driven equipment will be damaged by reverse operation.

3.03 CHECK-OUT TAGS

A. Upon receipt of equipment attach a "Check-Out Tag" to each piece of equipment which has an equipment number assigned.

B. On completion of each phase of the installation, enter the appropriate information on the tag. Include test results or make cross-reference to appropriate test form in the 'Remark' section.

C. Tag: size 90 mm x 215 mm, yellow coloured tag stock with metal reinforced eye. A sample tag is shown on Form 16030-Y.

3.04 COORDINATION OF PROTECTIVE DEVICES

A. Not Used

3.05 LOAD BALANCE

A. Measure phase current to MCCs, panelboards with normal loads operating at time of acceptance. If load unbalance exceeds 15 percent, adjust branch circuit connections as required to obtain best balance of current between phases and record changes.

B. Measure phase voltages at loads and arrange for adjustment of transformer taps to within 2 percent of rated voltage of equipment.

C. Submit, at completion of Work, a report listing phase and neutral currents on panelboards, switchboards, transformers and motor control centres, operating under normal load. State hour and date on which each load was measured, and voltage at time of test.

3.06 MINIMUM TEST REQUIREMENTS

A. The tests stipulated in this section are minimum requirements.

B. Conduct additional tests recommended by equipment manufacturers or as deemed necessary by the Contract Administrator as construction progresses.

3.07 INSULATION RESISTANCE MEASUREMENTS

A. General

1. Prior to energizing the equipment, conduct insulation resistance measurements on conductors and energized parts of electrical equipment. Minimum acceptable values of insulation resistance shall be in accordance with the applicable ICEA, EEMAC or ANSI standards for the equipment or material being tested, unless otherwise specified. Record the ambient temperature at which insulation resistance is measured on the test form.
2. Record insulation resistance measurements on the appropriate forms. Insulation with resistance of less than 10 megohms is not acceptable.

B. Test Instruments

1. Unless otherwise specified, use the following insulation resistance testers (Megger):
   a. 500 V instrument for circuits, feeders and equipment up to 350 V.
   b. 1000 V instrument for 350-600 V circuits, feeders and equipment.

C. Conductor and Cable Tests

1. Measure the phase-to-ground insulation resistance for all circuits 120 volts and above except lighting circuits. Measurements may be made with motors and other equipment connected. Disconnect solid state equipment unless the equipment is normally tested by the manufacturer at voltages in excess of 1000 volts DC.
2. Check phase rotation and identify each phase conductor of each feeder.
3. Check each feeder for continuity, short circuits and grounds.
4. After installing cable but before splicing and terminating, perform insulation resistance test on each phase conductor.
5. Check insulation resistance after each splice and/or termination to ensure that cable system is ready for acceptance testing.
6. Replace entire length of cable if cable fails to meet any of test criteria.

D. 1 kV and 600 V Power Cables:

1. Refer also to MCC tests.

E. 25 & 5 kV Cables (before terminations are complete)

1. Not Used

3.08 TRANSFORMERS

A. Not Used

3.09 CIRCUIT BREAKERS (ALL VOLTAGES)

A. Visually inspect all connections and assemblies and check all manual operations and physical interlocks on circuit breakers as specified.

B. Check all electrical controls, including anti-pump and trip free operation.

C. Check correct position indication.

D. Verify trip settings from each protective device.

3.10 LOADBREAK SWITCHES AND DISCONNECTS (ALL VOLTAGES)

A. Check all manual operations and physical interlocks.

B. Check correct position indication.

3.11 POTENTIAL AND CURRENT TRANSFORMERS (ALL VOLTAGES)

A. Verify winding ratio (nameplate rating).

B. Verify terminal polarity.

C. Check insulation resistance.

D. Verify grounding

3.12 PROTECTIVE RELAYS

A. Not Used

3.13 SWITCHBOARD METERING

A. Not Used

3.14 MOTOR CONTROL CENTRES AND CIRCUITS

A. Verify continuity of wiring.

B. Verify correctness of operation by operation of all controls, interlocks and automatic devices.

C. In the cases of motor starters, make these tests with starter racked out and with control fuse removed, using a temporary "foreign" control supply.

D. With the incoming feeder cable disconnected, with all feeder switches and motor starters racked in, with all feeder switches and motor starter contactors open and with ground detector and voltmeter fuses removed, Megger between phases and each phase to ground. Megger readings shall be 10 megohms or higher.

E. With the load end of each cable connected to the load (motor etc.) and with the contactor or switch open, Megger the outgoing feeder cables and motor windings to ground by connecting the Megger to the load side terminals of the starter or switch. Test only one phase on motor starters, and all three phases on fused switch feeder units. Megger readings shall be 5 megohms or higher.

F. Verify phase rotation.

G. Visually inspect fuses and verify overload settings with motor nameplate data. Verify MCP settings.

3.15 VARIABLE FREQUENCY DRIVES

A. Conduct tests and record information listed in Form 16030-Z and provide certification from the VFD manufacturer that the VFD equipment has been properly installed and tested.

1. Verify continuity of wiring.
2. Verify correctness of operation of all controls, interlocks.
3. Adjust all setpoints, minimum frequency, maximum frequency, acceleration time, deceleration time, output current, constant speed, for each variable frequency drive based on the process requirements.
4. Ensure moving and working parts are lubricated where required.
5. Functional testing of each VFD system to applicable CSA and IEEE standards, with the motor connected.

3.16 AC MOTORS

A. Check for proper lubrication.

B. Check for direction of rotation, verify correct rotation.

C. Check for vibration and excessive noise.

D. Measure the insulation resistance of all motors before they are connected. Motors 50 hp and larger shall have their insulation resistance measured at the time of delivery as well as when they are connected. Insulation resistance values less than 10 megohms are not acceptable.

E. With the incoming feeder cable disconnected, with all feeder switches and motor starters racked in, or connected, with all feeder switches and motor starter contactors open and with ground detector and voltmeter fuses removed, Megger between phases and each phase to ground. Megger readings shall be 10 megohms or higher.

F. With the load end of each cable connected to the motor and with the contactor or switch open, Megger the outgoing feeder cables and motor windings to ground by connecting the Megger to the load side terminals. Test/record one phase on motor starters, all three phases on fused switch feeder units. Megger readings shall be 5 megohms or higher.

3.17 POWER FACTOR TESTING

A. Not Used

3.18 CALIBRATION AND VERIFICATION

A. Description

1. Calibrate and verify the following equipment supplied under this Contract:
   a. MCCs
   b. VFDs
   c. LV Soft Starters
   d. Electrical Monitoring Equipment

B. Conduct the calibration and verification in the field after installation and connection of equipment, but prior to energization, in the presence of the Contract Administrator.

C. Qualifications

1. Perform the Work by a firm specializing in, and with relevant experience in, testing L.V. switchgear.

D. Calibration and Verification

1. Conduct the calibration and verification in the following stages:
   a. Power distribution transformers
   b. Motor control centre
   c. Variable frequency drives.
2. Advise Contract Administrator well in advance when each stage is ready for the calibration and verification and:
   a. Ensure that all equipment is installed, connected and cleaned inside and out.
   b. Ensure that the specified tests have been carried out.
   c. Provide 120V power for test purposes.
   d. Provide qualified personnel to assist in the calibration and verification.
   e. Provide all other facilities, equipment and personnel as reasonably required to assist in the calibration and verification.
3. Verify all transformer ratios, insulation values, fuse sizes, C.T. and P.T. ratios, etc. and certify that the installation is in accordance with the requirements of the manufacturer and the Coordination/Short Circuit Study. Submit a written report on this verification to the Contract Administrator.
4. Carry out the tests required of calibration and verification firm as specified in the other related sections.
5. Ensure all bus and cable connections are tightened to manufacturer's specifications.

6. Clean all relays with dry, dust-free compressed air.

E. Supplements

1. The supplements following “End of Section” form part of this Section.
   a. 16030-01 - Installed VFD Test

END OF SECTION

VFD EQUIPMENT NO. _____ DATE OF TEST _____

DRIVEN MOTOR EQUIPMENT NO. _____

DRIVEN LOAD CHARACTERISTIC: CONSTANT TORQUE _____

VARIABLE TORQUE _____

SETPOINTS:
MINIMUM FREQUENCY _____ Hz

MAXIMUM FREQUENCY _____ Hz

ACCELERATION TIME _____Sec

DECELERATION TIME _____ Sec

SPEED RANGE: MANUAL ____ RPM, _ RPM
CDACS _____RPM, _ RPM

VFD CURRENT AT FULL LOAD: PH.A. _____ Amp, PH.B _____ Amp, PH.C _____ Amp.

MOTOR CURRENT: PH.A. _____ Amp, PH.B _____ Amp, PH.C _____ Amp.

MOTOR NAMEPLATE DATA:

MFR.: _____ MFR. TYPE _____ FRAME _____ hp _____
VOLTS: _____ PHASE _____ RPM _____ SERVICE FACTOR _____

AMPS _ FREQ. Hz AMBIENT TEMP. RATING _____ °C

TIME RATING _____ DESIGN LETTER _____

kVA CODE LETTER _ INSULATION CLASS _____

CERTIFIED _____ Date _____
Contractor's Representative

WITNESSED _____ Date _____
Contract Administrator

PART 1. GENERAL (NOT USED).

PART 2. PRODUCTS

2.01 CONDUIT

A. Provide conduit of types and sizes indicated. Refer to Conduit Schedule at end of Section. Where sizes are not indicated, select proper sizes to suit intended use, fulfill wiring requirements, and comply with CEC.

B. EMT: to CSA C22.2 No.83-M1985. Provide rain-tight fittings.

C. Rigid Metal: to CSA C22.2 No.45-M1981.

D. Rigid PVC (Unplasticized): to CSA C22.2 No.211.2-M1984.

E. Flexible Metal Conduit: to CSA C22.2 No. 56-1977.

F. Polyethylene Pipe: to CSA B137.1-95, minimum series 75.

G. Flexible Plastic Underground Power Cable Ducting: to CSA C22.2 No. 211.1 1984.

2.02 WIRE AND CABLE

A. Building Wiring: to CSA C22.2 No. 75-M1983, copper conductor, 600 V RW90 X-link insulation. Use in all locations, except for underground wire which shall be RW90 X-Link -40°C, T90 Nyon or TWU75 -40°C.

B. Wire Sizing: according to CEC except where otherwise indicated. Minimum wire size for power circuits shall be #12 AWG.

C. Do not use metallic or non-metallic sheathed cables or wire with aluminum conductors, except where otherwise indicated.

2.03 BOXES AND FITTINGS

A. Provide boxes and fittings suitable for intended use and area installed and as follows:

1. Outlet Boxes: to CSA C22.2 No. 18-92. cast metal boxes for surface and weatherproof boxes.
2. Pull and Junction Boxes: to CSA C22.2 No. 40-M1989. Sheet steel with screw-on covers and barriers as required.
3. Bushings, Knockout Closures, and Locknuts: to CSA C22.2 No. 18-92.

2.04 WIRING DEVICES

A. Specification grade and as follows:

1. Switches: to CSA C22.2 No. 111-M1986, toggle type, 15 A, 125 V, full load rated, ivory colour.
2. Receptacles: to CSA C22.2 No. 42-M1984, duplex, 15 A, 125 V, U-ground, ivory colour.
3. Cover Plates: cast or polycarbonate, gasketed.

2.05 DISCONNECTS

A. Disconnects: to CAN/CSA C22.2 No.4-M89, heavy duty, lockable, non-fused, with poles, voltage, amperage, kw ratings and enclosures as indicated on drawings and required by CEC to suit application.

2.06 CABINETS AND ENCLOSURES

A. Cabinets and Enclosures: to CSA C22.2 No. 40-M1989, and as follows:

1. EEMAC-3R or EEMAC-4 sheet steel with hinged cover, flush lock and latch.
2. Backboards: 19 mm GIS plywood, as indicated on drawings, painted grey.

2.07 GROUNDING EQUIPMENT

A. Grounding Equipment: to CSA C22.2 No. 41-M1987 and as follows:

1. Conductors: copper, stranded, bare or insulated as indicated.
2. Connectors: thermaweld where underground or exposed to moisture, compression type bolt-on in other locations.

2.08 SUPPORTING DEVICES

A. Provide metal brackets, frames, clamps, channels, straps and related devices to adequately support weight of equipment and raceways.

PART 3. EXECUTION

3.01 CONDUIT

A. Except where otherwise indicated, install all wiring in conduit.

B. Install conduit parallel or at right angles to building lines; minimize crossovers and conserve space and headroom.

C. Install underground conduit minimum 1 m below finished grade.

D. Mount conduit on underside of metal roof deck by fastening to bottom of metal flutes.

3.02 BOXES

A. Install boxes flush where practicable and for vertical mounting of devices. Install to nearest course line in masonry walls.

B. Except where otherwise indicated, mount boxes at following heights to centreline of device:

1. Switches: 1,200 mm.
2. Receptacles in finished areas: 300 mm.

C. Contract Administrator may change location of outlets prior to installation, with no change in Contract Price, provided that distance does not exceed 3 m from originally indicated location.

3.03 WIRING DEVICES

A. Install devices and covers flush and level.

B. Ensure that outlet boxes are clean prior to installing devices.

3.04 GROUNDING

A. Provide service ground grid consisting of three ground rods spaced at least 1 m apart and connected by a #2/0 bare conductor.

B. Provide separate, insulated ground conductor in conduit installed underground, in slabs poured on grade or exposed to moisture and in non-metallic conduit.

C. Ground all metal parts of building structure and mechanical equipment.

3.05 SUPPORTS

A. Do not fasten supports to piping, ductwork or mechanical equipment.

3.06 CONDUIT SCHEDULE

Conduit Type	Locations
Rigid metal	Where exposed and subject to mechanical damage and in areas designated as hazardous.
Rigid PVC (Unplasticized)	Underground. Corrosive areas. Concrete slabs which are on grade or exposed to moisture.
Flexible metal or Liquidtite Flex	Connections to luminaires, motors and subject to vibration. Use Liquiditite Flex in process areas.
Polyethylene pipe or flexible plasticUnderground power	Mechanical protection of direct buried conductors
EMT	EMT is not acceptable

END OF SECTION

PART 1. GENERAL

1.01 SUMMARY

A. Comply with Division 1 - General Requirements and Section 16050 - Basic Electrical Equipment.

1.02 REFERENCES

A. CSA C22.2 No. 131 Type TECK 90 Cables.

B. CSA C22.2 No. 38 Thermoset Insulated Wires and Cables.

C. CSA C68.3 Power Cables with Thermoset Insulation.

D. CSA C21.1 600 V Control Cable.

1.03 DESIGN REQUIREMENTS

A. Number and sizes of wires (and associated raceways) indicated are a guide only and are not necessarily the exact number and sizes required. Wire or cable sizes smaller than indicated are not acceptable.

B. Unless otherwise indicated, combine motor branch power wiring (below 1,000 V systems) and associated local operator control or field control device wiring into a common conduit between motor and its starter or motor control centre, provided all of the following conditions are met:

1. Motor circuit voltage does not exceed 600 V.
2. Conductors and termination fittings for power and control circuits are rated 600 V minimum.
3. Control circuits are designed to operate at 120 V AC or higher. Install wiring for control circuits operating below 100 V AC or with DC in a separate conduit system.
4. Control circuit wiring solely associated with respective motor or heater. Install wiring for control circuits of other equipment and systems, or wiring common to two or more pieces of equipment in separate conduits.

C. Supply spare conductors in control, communication and instrumentation cable circuits as follows:

1. Up to four utilized conductors in one conduit or cable: one spare conductor.
2. Five to eight utilized conductors in one conduit or cable: two spare conductors.
3. Nine or more utilized conductors: 20% or three spare conductors, whichever is greater.

1.04 STORAGE

A. Cap cable ends to prevent water penetration into cable. Reseal after cutting length of cable.

B. Cables stored with ends unsealed will be immediately removed from Site at contractors cost. At no extra cost to the City, replace cables to the satisfaction of the Engineer.

PART 2. PRODUCTS

2.01 MANUFACTURED PRODUCTS

A. Comply with standards listed in 1.02, References.

B. Low Voltage Unarmoured Wire and Cable (1000 V and Below)

1. Acceptable manufacturers: Phillips Cables Limited, Alcatel Canada Wire Inc., Pirelli Cables Inc., United Wire of Canada.
2. Construction: Stranded, annealed copper conductors, 600 V minimum rating for #14, #12 and #10 AWG and 1000 V rating for conductors larger than #10 AWG, RW90 cross-linked polyethylene (XLPE) insulation, suitable for handling at minus 40°C ambient, 90°C maximum conductor temperature.
3. Direct buried installations or installation in direct buried polyethylene pipe: Cross-linked polyethylene (XLPE), RWU90 insulation, 1,000 V minimum rating.
4. Standard: CSA C22.2 No. 38.
5. Minimum conductor sizes: Unless otherwise indicated, #12 AWG for power and current transformer circuits; #16 AWG for control circuits; telephone wiring to comply with telephone utility standards.
6. Multi-conductor cables: PVC flame retardant black jacket overall, suitable for handling at minus 40°C, flame test rated FT4.
7. Colour coding: For insulated conductors, conform to the following:
   a. 1-conductor power - Black (Phase Conductors)
      - White (Neutral)
   b. 1-conductor control - Red
   c. 2-conductor power - Black, White
   d. 3-conductor power - Red, Black, White (Neutral)
      - Red, Black, Blue
   e. 4-conductor power - Red, Black, Blue, White
   f. Multi-conductor cables - Manufacturer's standard
   g. Insulated ground conductors forming part of a multi-conductor cable assembly: Inspection Authority colour coding.

C. Low Voltage Armoured Wire and Cable (1000 V and Below)

1. Acceptable manufacturers: Phillips Cables Limited, Alcatel Canada Wire Inc., Pirelli Cables Inc., United Wire and Cable.
2. Construction: Stranded, annealed copper conductors, 1000 V rating, RW90 cross-linked polyethylene (XLPE) insulation, suitable for handling at minus 40°C ambient, 90°C maximum conductor temperature, flame test rated FT4.
3. Power cabling: TECK construction.
4. Control cabling: TECK construction.
5. Minimum conductor size: Unless otherwise indicated, #12 AWG for power and current transformer circuits and #16 AWG for control circuits.
6. Grounding conductor: Stranded, soft, bare copper conductor in multiconductor cables, concentric copper wires over insulation in single conductor cable.
7. Multi-conductor cables: With inner jacket of suitable PVC (minus 40°C).
8. Interlocking armour: Flexible, galvanized steel or aluminum for multi-conductor cables and aluminum for single conductors, spirally wound over inner jacket.
9. Outer jacket: PVC (minus 40°C), flame-retardant, FT4 flame test rated, low acid gas evolution, black outer jacket extruded over the armour.
10. Colour coding: For insulated conductors, conform to the following:

a.	1-conductor power	- Black
b.	1-conductor control	- Red
c.	2-conductor cable	- Black, White
d.	3-conductor cable	- Red, Black, White (Neutral) - Red, Black, Blue
e.	4-conductor cable	- Red, Black, Blue, White
f.	Multi-conductor cables	- Manufacturer's standard

D. Instrumentation Wiring

1. Conductors: #16 AWG, 7 strand minimum, tinned copper, unless otherwise indicated, 300 V minimum insulation.
2. Construction: Twisted pair, triplet and quad grouping with nominal 50 mm staggered lay and 100% aluminum-Mylar tape shield with minimum 25% overlap.
3. Drain wire: Over each group, bare, #20 AWG minimum, tinned copper, in direct continuous contact with shield.
4. Jacket: PVC (-40°C) low acid gas, FT4 rated low flame spread.
5. Identification: Each grouping (pair, triplet, quad) by consecutive number coding, permanently marked at 25 mm intervals.
6. Armour: For exposed or direct buried cables, aluminum or steel interlocking

armour with overall PVC jacket.

7. General purpose instrumentation cable: Type #9316 by Belden Wire and Cable.
8. RS232 and RS422 cables: 4 pair, 22 AWG stranded copper, separately twisted pairs, overall 100% aluminum-polyester shield, tinned copper stranded drain wire, type #9305 by Belden Wire and Cable.
9. Termination fittings: Type, configuration and gender required to connect cable directly to equipment without additional adapters or fittings.

E. Thermocouple Wiring

1. Not Used

F. Wiring Accessories

1. Wire markers: Plastic slip-on, black letters on white background. Shur-Code by Thomas & Betts Ltd., Z-Type by Wieland Electric Inc.
2. Cable markers: For cables or conductors greater than 13 mm diameter, strap-on type, semi rigid PVC carrier strip. Type K by Wieland Electric Inc.
3. Terminal blocks: 600 V, 25 A minimum rating, modular, 35 mm DIN rail mounted, provision for circuit number labelling, individually removable, sized to accommodate conductor size and circuit current. Sak Series by Weidmuller Ltd., UK Series by Phoenix Terminal Blocks Ltd., WK Series by Wieland Electric Inc., Entrelec.
4. Field wiring terminations: Where screw-type terminal blocks are provided, supply insulated fork tongue terminals. Sta-Kon by Thomas & Betts Ltd., Scotchlok by 3M Canada Inc.
5. Splice connectors for equipment pig-tail, lighting and receptacle circuits: For wire sizes #12 and #10 AWG inclusive, twist-on compression spring type. Wing-Nut by Ideal., Marrette Type II by Marr Electric Ltd.
6. Moisture and waterproofing: In wet locations, with Liquid Tape by Ideal.
7. Equipment pig-tail power circuit connections: For wire sizes #8 AWG minimum, split-bolt type, sized to suit number and size of conductors. Servit Type KS by Burndy Inc.
8. Cable ties: Nylon, one-piece, self-locking type, by Thomas & Betts Ltd., Burndy Inc., Wieland Electric Inc.
9. TECK cable connectors in wet or outdoor areas: Watertight type.

PART 3. EXECUTION

3.01 INSTALLATION

A. Provide wires of number and size (including corresponding raceways) required, with spare conductors as indicated. Provide adequate wiring for actual equipment installed.

B. Provide wire and cable according to the Drawings and electrical system requirements.

C. Pull cable into ducts, conduits and cable trays in accordance with cable manufacturer's recommendations. Use patented cable grips suitable for cable type, or pulling eyes fastened directly onto cable conductors.

D. Limiting pulling tension and minimum bending radii to those recommended by manufacturer.

E. Prevent damage to cable jackets by utilizing adequate lubricant when pulling cables through ducts and conduits.

F. Connect cables to electrical boxes and equipment enclosures located in wet or sprinkled areas with watertight cable connectors.

G. Install through wiring in junction and pull boxes having no connection within the box. Leave 150 mm minimum of slack inside box.

H. Facilitate making of joints and connections by leaving sufficient slack in each conductor at panelboards, outlet boxes and other devices.

I. Install instrumentation signal and thermocouple extension wires in separate raceways from power and control wiring.

J. Provide mechanical protection for cables within 1,500 mm of the floor in buildings and within 2,000 mm above grade outdoors.

K. Identify each cable by attaching a cable marker at each end, in all intermediate manholes, junction boxes and pull boxes.

3.02 UNDERGROUND INSTALLATION

A. Install direct buried cables in 75 mm layers sifted sand, free of rock, stone and other sharp objects, above and below.

B. Protect direct buried cables with 50 mm thick treated planks. Extend protection 50 mm minimum on either side of cabling.

C. Install direct buried cable at depth of 600 mm minimum. Where rock is encountered and minimum depth cannot be attained, install cables in concrete encased ducts.

3.03 WIRING TERMINATIONS

A. Insulate equipment pig-tail power circuit connections with wire sizes #8 AWG and larger, with heat shrink sleeving termination kits.

B. Terminate armoured cables with accepted connectors suitable for application, size and type of cable.

C. Except where pulling tensions exceed allowable cable limits or where tap connections are required, only install splices in power, control and instrumentation cable runs with written permission of Engineer. Where unavoidable, install splices in junction boxes only.

D. Make power, control and instrumentation wiring taps, splices and terminations in junction boxes with labelled terminal blocks, securely fastened to avoid loosening under vibration or normal strain. Terminate lighting circuits and 120 V convenience receptacle circuits with twist on or split-bolt type connectors and insulating tape.

E. Terminate control, signal and instrumentation circuit conductors, including spares, on terminal blocks. Label terminal blocks with unique alphanumeric designation or as indicated.

F. Identify each conductor, including spares, by wire markers at each termination. Indicate circuit designation or unique wire number. Identify spare conductors as ‘SP1’, ‘SP2’, etc.

3.04 TESTING

A. Cable and Wire – 1,000 Volt and Below

1. Conduct insulation resistance measurements using a “Megger” (500 V instrument for circuit up to 350 V systems, 1,000 V instrument for 351-600 V systems).
2. Record test results in a log book and submit to Engineer for reference. Replace or repair circuits which do not meet Inspection Authority requirements. With equipment disconnected, measure insulation resistance of the following circuits:
3. Power, lighting, heater and motor feeders: Phase-to-phase, phase-to-ground.
4. Control circuits: To ground only.
5. Do not perform “Megger” tests on equipment containing solid-state components.
6. Disconnect power factor correction capacitors from system prior to testing.

B. Instrumentation and Thermocouple Extension Wiring

1. Check continuity of each conductor using ohmmeter or DC buzzer. Megger or 120 volt filament lamp testing is not acceptable.
2. Test thermocouple wiring for continuity and polarity in accordance with manufacturer’s recommendations.

3.05 WIRING IDENTIFICATION

A. Identify wiring including fibre optic cabling, with wire markers.

B. Colour code power, feeder and branch conductors at both ends with coloured plastic tapes. Tapes are not required where conductors are identified by jacket colour. Maintain phase and colour sequence throughout.

C. Identify each conductor, including spares, with a unique numeric designation to facilitate troubleshooting and maintenance.

D. Identify PLC wiring at terminal blocks and connection points with PLC terminal (I/O) address numbers.

3.06 WIRING SIGNAL LEVEL SEPARATION

A. Not Used

END OF SECTION

PART 1. GENERAL

1.01 RELATED SECTIONS

A. This section applies only when referenced by a motor-driven equipment specification. Application, horsepower, enclosure type, mounting, shaft type, synchronous speed, and any deviations from this section will be listed in the equipment specification. Where such deviations occur, they shall take precedence over this section.

1.02 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. CSA C22.2 No. 100, Motors and Generators.
2. CSA C390, Energy Efficiency Test Methods for Three-Phase Induction Motors.
3. American Bearing Manufacturers Association (ABMA):
   a. 9, Load Ratings and Fatigue Life for Ball Bearings.
   b. 11, Load Ratings and Fatigue Life for Roller Bearings.
4. Institute of Electrical and Electronics Engineers, Inc. (IEEE):
   a. 112, Standard Test Procedures for Polyphase Induction Motors and Generators..
   b. 620, Guide for the Presentation of Thermal Limit Curves for Squirrel Cage Induction Motors.
5. National Electrical Manufacturers Association (NEMA):
   a. MG 1, Motors and Generators.
   b. MG 13, Frame Assignments for Alternating Current Integral Horsepower Induction Motors.
   c. 250, Enclosures for Electrical Equipment (1,000 Volts Maximum).
6. CANADIAN Electrical Code. (CEC).
7. Underwriters Laboratories (UL):
   a. 1, Flexible Metal Conduit.
   b. 674, Standard for Safety Electric Motors and Generators for use in Division 1 Hazardous (Classified) Locations.
   c. 2111, Overheating Protection for Motors.
8. EEMAC Standard M1-6, Motors and Generators.
9. EEMAC Standard MG2, Safety Standard for Construction and Guide for Selection, Installation and Use of Electric Motors and Generators.

1.03 DEFINITIONS

A. CISD-TEFC: Chemical industry, severe-duty enclosure.

B. DIP: Dust-ignition-proof enclosure.

C. EXP: Explosion-proof enclosure.

D. ODP: Open drip-proof enclosure.

E. TEFC: Totally enclosed, fan cooled enclosure.

F. TENV: Totally enclosed, nonventilated enclosure.

G. WPI: Open weather protected enclosure, Type I.

H. WPII: Open weather protected enclosure, Type II.

I. Motor Nameplate Horsepower: That rating after any de-rating required to allow for extra heating caused by the harmonic content in the voltage applied to the motor by its controller.

J. Inverter Duty Motor: Motor meeting all applicable requirements of NEMA MG 1, Section IV, Parts 30 and 31.

1.04 DESIGN REQUIREMENTS

A. Design equipment, anchorage, and support systems for vertical and lateral loading in accordance with

1.05 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
    a. Descriptive information.
    b. Nameplate data in accordance with NEMA MG 1.
    c. Additional Rating Information:
        1) Service factor.
        2) Locked rotor current.
        3) No load current.
        4) Safe stall time

5) Multi-speed load classification (e.g. variable torque) and minimum allowable motor speed for that load classification.
6) Guaranteed minimum full load efficiency and power factor.

d. Enclosure type and mounting (e.g. horizontal, vertical).
e. Dimensions and total weight.
f. Conduit box dimensions and usable volume as defined in NEMA MG 1.
g. Bearing type.
h. Bearing lubrication.
i. Bearing life.
j. Space heater voltage and watts.
k. Description, ratings, and wiring diagram of motor thermal protection.
l. Motor sound power level in accordance with NEMA MG 1.
m. Maximum brake horsepower required by the equipment driven by the motor.

B. Information Submittals:

1. Factory test reports (certified).
2. Operation and maintenance data.

PART 2. PRODUCTS

2.01 MANUFACTURERS

A. GE Canada.

B. Leeson Canada.

C. Reliance Electric.

D. MagneTek.

E. Siemens Energy and Automation, Inc., Motors and Drives Division.

F. Baldor.

G. U.S. Electrical Motors.

H. TECO-Westinghouse Motor Co.

I. Toshiba International Corp., Industrial Division.

J. WEG Electric Motors Corp.

2.02 GENERAL

A. For multiple units of the same type of equipment, furnish identical motors and accessories of a single manufacturer.

B. In order to obtain single source responsibility, utilize a single supplier to provide a drive motor, its driven equipment, and specified motor accessories.

C. Meet requirements of NEMA MG 1.

D. Frame assignments in accordance with NEMA MG 1.

E. Motors shall be specifically designed for the use and conditions intended, with a NEMA design letter classification to fit the application.

F. Lifting lugs on all motors weighing 45 kg or more.

G. Operating Conditions:

1. Maximum ambient temperature not greater than 40 degrees C.
2. Motors shall be suitable for operating conditions without any reduction being required in the nameplate rated horsepower or exceeding the rated temperature rise.
3. Overspeed in either direction in accordance with NEMA MG 1.

2.03 HORSEPOWER RATING

A. As designated in motor-driven equipment specifications.

B. Adjustable Frequency and Adjustable Speed Applications (Inverter Duty Motor): Driven equipment brake horsepower at any operating condition not to exceed motor nameplate horsepower rating, excluding any service factor.

2.04 SERVICE FACTOR

A. 1.15 minimum at rated ambient temperature, unless otherwise indicated.

2.05 VOLTAGE AND FREQUENCY RATING

A. System Frequency: 60-Hz.

B. Voltage Rating: Unless otherwise indicated in motor-driven equipment specifications:

Size	Voltage	Phases
0.37 kW and smaller	115	1
0.56 kW through 298 kW	575	3

C. Suitable for full voltage starting..

D. Suitable for accelerating the connected load with supply voltage at motor starter supply terminals dipping to 90 percent of motor rated voltage.

2.06 EFFICIENCY AND POWER FACTOR

A. For all motors except single-phase, under 0.74 kW, multispeed, short-time rated and submersible motors, or motors driving gates, valves, elevators, cranes, trolleys, and hoists:

1. Efficiency:
   a. Tested in accordance with CSA C390, paragraph 12.59.
   b. Guaranteed minimum at full load in accordance with NEMA MG or as indicated in motor-driven equipment specifications.
2. Power Factor: Guaranteed minimum at full load in accordance with Table 1 or as indicated in motor-driven equipment specifications.

2.07 LOCKED ROTOR RATINGS

A. Locked rotor kVA Code G or lower, if motor horsepower not covered by NEMA MG 1 tables.

B. Safe stall time 12 seconds or greater.

2.08 INSULATION SYSTEMS

A. Single-Phase, Fractional Horsepower Motors: Manufacturer's standard winding insulation system.

B. Motors Rated Over 600 Volts: Sealed windings in accordance with NEMA MG 1.

C. Three-Phase and Integral Horsepower Motors: Unless otherwise indicated in motor-driven equipment specifications, Class B or Class F at nameplate horsepower and designated operating conditions

2.09 ENCLOSURES

A. Enclosures to conform to NEMA MG 1.

1. TEFC and TENV: Furnish with a drain hole with porous drain/weather plug.

2.10 TERMINAL (CONDUIT) BOXES

A. Oversize main terminal boxes for all motors.

B. Diagonally split, rotatable to each of four 90-degree positions. Threaded hubs for conduit attachment.

C. Except ODP, furnish gaskets between box halves and between box and motor frame.

D. Minimum usable volume in percentage of that specified in NEMA MG 1, Section 1, Paragraph 4.19:

Terminal Box Usable Values		
Voltage	**Horsepower**	**Percentage**
Below 600	(11.2 to 93.2 kW)	500
Below 600	(111.8 to 223.7 kW)	275
Above 600	All sizes	200

E. Terminal for connection of equipment grounding wire in each terminal box.

2.11 BEARINGS AND LUBRICATION

A. Horizontal Motors:

1. 0.56 kW and Smaller: Permanently lubricated and sealed ball bearings, or regreasable ball bearings in labyrinth sealed end bells with removable grease relief plugs.
2. 0.74 Through 298 kW: Regreasable ball bearings in labyrinth sealed end bells with removable grease relief plugs.
3. Above 298 kW: Regreasable antifriction bearings in labyrinth sealed end bells with removable grease relief plugs.
4. Minimum 100,000 hours L-10 bearing life for ball and roller bearings as defined in ABMA 9 and 11.

B. Vertical Motors:

1. Thrust Bearings:
   a. Antifriction bearing.
   b. Manufacturer's standard lubrication 74 kWand smaller.
   c. Oil lubricated 93kW and smaller.
   d. Minimum 50,000 hours L-10 bearing life.
2. Guide Bearings:
   a. Manufacturer's standard bearing type.
   b. Manufacturer's standard lubrication 149kW and smaller.
   c. Oil lubricated 186 kW and smaller.
   d. Minimum 100,000 hours L-10 bearing life.

C. Regreasable Antifriction Bearings:

1. Readily accessible, grease injection fittings.
2. Readily accessible, removable grease relief plugs.

D. Oil Lubrication Systems:

1. Oil reservoirs with sight level gauge.
2. Oil fill and drain openings with opening plugs.
3. Provisions for necessary oil circulation and cooling.

E. Bearing Isolation: Motors rated for inverter duty shall have electrically isolated bearings to prevent stray current damage.

2.12 NOISE

A. Measured in accordance with IEEE 85 and NEMA MG 1.

B. Motors controlled by adjustable frequency drive systems shall not exceed sound levels of 3 dBA higher than NEMA MG 1.

2.13 BALANCE AND VIBRATION CONTROL

A. In accordance with NEMA MG 1, Part 7.

2.14 EQUIPMENT FINISH

A. External Finish: Prime and finish coat manufacturer's standard.

B. Internal Finish: Bore and end turns coated with clear polyester or epoxy varnish.

2.15 SPECIAL FEATURES AND ACCESSORIES

A. Nameplates:

1. Raised or stamped letters on stainless steel or aluminum.
2. Display motor data required by NEMA MG 1, paragraphs 10.39 and 10.40 in addition to bearing numbers for both bearings.
3. Premium efficiency motor nameplates to also display NEMA nominal efficiency, guaranteed minimum efficiency, full load power factor, and maximum allowable kVAR for power factor correction capacitors.

B. Anchor Bolts: Provide anchor bolts meeting manufacturer's recommendations and of sufficient size and number for the specified seismic conditions.

2.16 FACTORY TESTING

A. Tests:

1. In accordance with CSA C390 for polyphase motors and for single-phase motors.
2. Routine production tests on all motors in accordance with NEMA MG 1, plus no load power at rated voltage and polyphase, rated voltage measurement of locked rotor current. Test multispeed motors at all speeds.
3. For energy efficient motors, test efficiency at 50, 75, and 100 percent of rated horsepower:
   a. In accordance with CSA C390 or IEEE 112, Test Method B, and NEMA MG 1, paragraphs 12.59. and 12.60.
   b. For motors 373 kW and larger where facilities are not available to test by dynamometer (Test Method B), determine efficiency by CSA C390 or IEEE 112, Test Method F.

4. Power Factor.
5. Speed.
6. Current at rated horsepower.
7. kW input at rated horsepower.

B. Test Report Forms:

1. Routine Tests: IEEE 112, Form A-1.

PART 3. EXECUTION

3.01 INSTALLATION

A. In accordance with manufacturer's instructions and recommendations.

B. Align motor carefully and properly with driven equipment.

C. Secure equipment to mounting surface with anchor bolts.

3.02 FIELD QUALITY CONTROL

A. Refer to Section 16030, Electrical Testing.

3.03 MANUFACTURER'S SERVICES

A. Furnish manufacturer's representative at Site for installation assistance, inspection, equipment testing, and startup assistance.

B. Manufacturer's Certificate of Proper Installation.

3.04 SUPPLEMENTS

A. Table supplements, following "End of Section," are part of this Specification.

1. Motor Performance Requirements.

END OF SECTION

MOTOR PERFORMANCE REQUIREMENTS									
		% Guar. Min. Full Load Efficiency				% Guar. Min. Full Load Power Factor			
		Horizontal		Vertical		Horizontal		Vertical	
hp (kW)	Nom.Speed rpm	Drip-proof ODP	TEFC	Drip-proof ODP	TEFC	Drip-proof ODP	TEFC	Drip-proof ODP	TEFC
1 (0.75)	1,800	85.5	85.5			Mfr.'s Std.	Mfr.'s Std.		
	1,200	82.5	82.5			Mfr.'s Std.	Mfr.'s Std.		
1.5 (1.12)	3,600	84.0	84.0			Mfr.'s Std.	Mfr.'s Std.		
	1,800	86.5	86.5			Mfr.'s Std.	Mfr.'s Std.		
	1,200	86.5	86.5		82.0	Mfr.'s Std.	Mfr.'s Std.		Mfr.'s Std.
2 (1.49)	3,600	85.5	85.5			Mfr.'s Std.	Mfr.'s Std.		
	1,800	86.5	86.5			Mfr.'s Std.	Mfr.'s Std.		
	1,200	87.5	88.5	83.7	83.7	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.
	900	82.9	82.5	82.9	81.7	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.
3 (2.24)	3,600	85.5	86.5	82.0	82.0	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.
	1,800	89.5	89.5	84.8	84.8	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.
	1,200	88.5	89.5	87.5	86.6	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.
	900	84.1	83.0	84.1	82.9	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.

MOTOR PERFORMANCE REQUIREMENTS									
		% Guar. Min. Full Load Efficiency				% Guar. Min. Full Load Power Factor			
		Horizontal		Vertical		Horizontal		Vertical	
hp (kW)	Nom.Speed rpm	Drip-proof ODP	TEFC	Drip-proof ODP	TEFC	Drip-proof ODP	TEFC	Drip-proof ODP	TEFC
5 (3.73)	3,600	86.5	88.5	84.8	84.8	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.
	1,800	89.5	89.5	84.8	84.8	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.
	1,200	89.5	89.5	87.5	86.6	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.
	900	87.5	85.5	87.5	86.6	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.
7.5 (5.59)	3,600	88.5	89.5	84.8	86.6	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.
	1,800	91.0	91.7	89.3	88.4	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.
	1,200	90.2	91.0	88.4	87.5	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.
	900	87.5	85.5	87.5	86.6	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.
10 (7.46)	3,600	89.5	90.2	89.3	88.4	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.
	1,800	91.7	89.5	89.3	88.4	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.
	1,200	91.7	89.5	89.3	88.4	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.
	900	89.3	88.5	89.3	88.4	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.

MOTOR PERFORMANCE REQUIREMENTS									
		% Guar. Min. Full Load Efficiency				% Guar. Min. Full Load Power Factor			
		Horizontal		Vertical		Horizontal		Vertical	
hp (kW)	Nom.Speed rpm	Drip-proof ODP	TEFC	Drip-proof ODP	TEFC	Drip-proof ODP	TEFC	Drip-proof ODP	TEFC
15 (11.18)	3,600	90.2	90.2	88.4	88.4	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.
	1,800	93.0	91.0	90.9	90.2	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.
	1,200	91.7	90.2	90.2	89.3	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.
	900	89.3	88.5	89.3	88.4	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.
20 (14.91)	3,600	92.4	90.2	90.9	89.3	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.
	1,800	93.0	91.0	91.7	90.9	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.
	1,200	91.0	90.2	90.2	89.3	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.
	900	90.2	89.5	89.3	88.4	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.
25 (18.64)	3,600	91.7	91.7	91.7	90.2	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.
	1,800	93.6	93.6	92.4	91.7	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.
	1,200	93.0	93.0	90.9	89.3	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.
	900	90.2	89.5	89.3	88.4	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.

MOTOR PERFORMANCE REQUIREMENTS									
		% Guar. Min. Full Load Efficiency				% Guar. Min. Full Load Power Factor			
		Horizontal		Vertical		Horizontal		Vertical	
hp (kW)	Nom.Speed rpm	Drip-proof ODP	TEFC	Drip-proof ODP	TEFC	Drip-proof ODP	TEFC	Drip-proof ODP	TEFC
30 (22.37)	3,600	91.7	91.7	89.5	88.4	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.
	1,800	94.1	93.6	92.4	91.7	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.
	1,200	93.6	93.0	91.7	90.2	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.
	900	91.7	91.0	90.9	90.9	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.
40 (29.83)	3,600	92.4	92.4	90.2	89.3	86.6	86.1	87.0	89.0
	1,800	94.1	94.1	92.8	91.7	78.2	78.2	83.0	84.5
	1,200	94.1	94.1	91.7	90.9	81.5	81.5	81.5	81.5
	900	91.7	91.0	90.9	90.2	70.0	70.5	70.0	70.5
50 (37.29)	3,600	93.0	93.0	90.2	89.3	85.1	86.7	89.0	89.0
	1,800	94.5	94.5	92.8	91.7	79.5	79.4	82.5	82.5
	1,200	94.1	94.1	91.7	90.9	81.5	81.5	81.5	81.5
	900	91.7	91.7	90.9	90.9	78.5	72.9	78.5	80.0

MOTOR PERFORMANCE REQUIREMENTS									
		% Guar. Min. Full Load Efficiency				% Guar. Min. Full Load Power Factor			
		Horizontal		Vertical		Horizontal		Vertical	
hp (kW)	Nom.Speed rpm	Drip-proof ODP	TEFC	Drip-proof ODP	TEFC	Drip-proof ODP	TEFC	Drip-proof ODP	TEFC
60 (44.74)	3,600	93.6	93.6	91.7	90.9	85.8	88.3	87.5	89.0
	1,800	95.0	95.0	93.5	92.8	80.5	79.9	80.5	80.5
	1,200	94.5	94.5	92.8	91.7	81.5	81.5	81.5	81.5
	900	92.4	91.7	91.7	90.9	79.5	73.2	79.5	79.5
75 (55.93)	3,600	93.6	93.6	91.7	91.7	87.1	88.5	88.5	88.5
	1,800	95.0	94.4	93.5	93.5	81.0	81.5	81.0	81.5
	1,200	94.5	94.5	93.5	92.8	82.0	82.0	82.0	82.0
	900	92.8	92.4	92.8	91.7	80.5	74.5	80.5	81.0
100 (74.57)	3,600	93.6	94.1	91.7	91.7	87.0	88.2	87.0	88.5
	1,800	95.4	95.4	94.0	93.5	81.0	81.0	81.0	81.0
	1,200	95.0	95.0	92.8	92.8	82.1	81.7	85.5	85.5
	900	93.5	92.4	92.8	91.7	77.0	77.3	77.0	80.0

MOTOR PERFORMANCE REQUIREMENTS									
		% Guar. Min. Full Load Efficiency				% Guar. Min. Full Load Power Factor			
		Horizontal		Vertical		Horizontal		Vertical	
hp (kW)	Nom.Speed rpm	Drip-proof ODP	TEFC	Drip-proof ODP	TEFC	Drip-proof ODP	TEFC	Drip-proof ODP	TEFC
125 (93.21)	3,600	94.1	95.0	91.7	91.7	86.4	89.1	87.0	90.5
	1,800	95.4	94.5	93.5	92.8	85.4	85.5	87.5	86.0
	1,200	95.0	95.0	93.5	92.8	82.7	82.3	85.5	85.5
	900	93.5	93.0	92.8	92.4	78.5	78.5	78.5	78.5
150 (111.86)	3,600	94.1	95.0	92.4	91.7	86.5	90.0	86.5	90.5
	1,800	95.8	95.8	94.5	94.0	82.5	85.0	84.5	85.0
	1,200	95.4	95.8	93.5	94.0	81.5	81.5	81.5	81.5
	900	93.5	93.0	92.8	92.4	78.0	78.5	78.0	78.5

PART 1. GENERAL

1.01 REFERENCES

A. Comply with the latest edition of the following statutes codes and standards and all amendments thereto.

1. EEMAC/NEMA Standard ICS 2.
2. CAN/CSA C22.2 No. 14 Industrial Control Equipment
3. CSA C22.2 No. 25A-05 Motor Control Centres.
4. American National Standard Institute (ANSI):
5. National Electrical Manufacturers Association (NEMA):
    a. AB1, Molded Case Circuit Breakers.
    b. ICS 1, General Standards for Industrial Control and Systems.
    c. ICS 2, Standards for Industrial Control Devices, Controllers, and Assemblies.
    d. ICS 2.3, Instructions for Handling, Installation, Operation, and Maintenance of Motor Control Centers
    e. ICS 18, Motor Control Center.
    f. KS 1, Enclosed and Miscellaneous Distribution Equipment Switches (600 Volts Maximum).
    g. 250, Enclosures for Electrical Equipment (1,000 volts maximum).

1.02 SUBMITTALS

A. Action Submittals:

1. Include a copy of this specification section with any applicable addenda updates with the low-voltage motor control submittal. Each paragraph shall be check - marked to show specification compliance or marked to show deviations. Attach a cross-referenced letter of explanation for deviations.
2. Itemized bill of material.
3. Descriptive information.
4. Dimensional drawings.
5. Front Panel Elevations.
6. Conduit entrance locations.
7. Bus data.
8. Protective Devices: Copies of time - current characteristics.
9. Typed Tabulation:
    a. Motor name; tag (equipment) numbers as shown on Drawings.
    b. Motor horsepower.
    c. Nameplate full load current.

d. Heater model number and relay setting.
e. Protective device trip settings.

10. Control diagrams.
11. One-line diagrams.
12. Schematic (elementary) diagrams.
13. Outline diagrams.
14. Anchoring instructions and details.

B. Submit bound and indexed copies of operating and maintenance manuals. Include the following:

1. Complete parts list.
2. Spare parts list.
3. Installation instructions.
4. Operating instructions.
5. Maintenance instructions.
6. Detailed troubleshooting procedures and fault correction schedules.
7. Final record drawings.
8. Certified test results.

C. Submit final record wiring diagrams at completion of project. Include changes made during field installation and start-up. Enclose one copy of wiring diagram in plastic envelope and leave in each starter compartment door pocket.

1.03 CSA COMPLIANCE

A. Products manufactured conform to CSA Standards and have an applied CSA or equivalent approved Listing Mark.

1.04 QUALITY ASSURANCE

A. Factory test individual components and complete MCC assembly in accordance with applicable standards.

B. Manufacturer to notify Contract Administrator 48 hours minimum, prior to tests.

C. Test MCC assembly in accordance with applicable Standards and include, but do not limit to, the following:

1. Interchangeability of removable elements.
2. Mechanical and electrical operation of circuit breakers, starters, drawout mechanism, interlocks, auxiliary switches, protective devices, manual devices.
3. Functional tests on components and circuits. Simulate control signals.
4. Continuity of power and control circuit wiring.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Shipping Splits: Established by Contractor to facilitate installation of equipment to final installation location.

PART 2. PRODUCTS

2.01 MANUFACTURERS

A. Materials, equipment, and accessories specified in this section shall be products of:

1. Allen-Bradley.
2. Eaton Electrical/Cutler-Hammer.
3. Schneider Electric/Square D Services.
4. Or Contract Administrator approved equal in accordance with B6.

2.02 GENERAL

A. Like Items of Equipment: End product of one manufacturer.

B. Make adjustments necessary to wiring, conduit, disconnect devices, motor starters, branch circuit protection, and other affected material or equipment to accommodate motors actually provided under this Contract.

C. Controllers: NEMA ICS 1, NEMA ICS 2, Class A.

D. Control Transformer:

1. Two winding, 120-volt secondary, primary voltage to suit.
2. Two current-limiting fuses for primary circuit.
3. One fuse in secondary circuit.
4. Mount within starter unit.

E. Suitable for use with 75 degrees C wire at full NFPA 70, 75 degrees C ampacity.

F. Lifting lugs on all equipment and devices weighing over 50 pounds.

G. Operating Conditions:

1. Ambient Temperature: Maximum 40 degrees C, Minimum -40 degrees C.
2. Altitude: 233.1 m (765 ft) above sea level.
3. Equipment to be fully rated.

H. Enclosures: In accordance with NEMA 250.

I. Equipment Finish:

1. Electrocoating process applied over rust-inhibiting phosphated base coating.
2. Exterior Color: Manufacturer's standard.

2.03 FILTERED POWER FACTOR CORRECTION CAPACITOR (PFCC)

A. Enclosed, outdoor, weatherproof, three-phase capacitor units.

B. Kilovar Ratings:

1. Check motor nameplate and manufacturer's power factor and no-load current data for actual motor installed.
2. Reduce capacitor rating, if required, to not exceed motor manufacturer's recommended maximum size, and to not exceed value required to raise motor no-load power factor to 0.95.

C. Iron core 3 phase reactors for harmonic contaminated environments.

D. IEC rated contactor (120 Volt control voltage by others).

E. HRC fusing.

F. Ventilation kit.

G. NEMA 3R galvanized enclosure

H. Manufacturers:

1. Electrotek Ltd.

2.04 VFD

A. Refer to Specification 16481 Low Voltage VFDs.

2.05 MOTOR CONTROL CENTERS

A. General:

1. In accordance with NEMA ICS 2, CSA C22.2 No. 14, and UL 845.
2. Voltage Rating: 600 volts.
3. Short Circuit Rating: 42,000 amperes rms symmetrical at 600 volts for entire motor control center as a complete assembly.
4. Main and branch circuit breakers, controllers, wire connections, and other devices to be front mounted and accessible, unless otherwise noted.

5. NEMA ICS 18, Part 3.
   a. Class: 11.
   b. Type: B.

B. Enclosure:

1. Type: CSA Type 3R, outdoor non-walk-in.
2. Construction:
   a. Sheet steel reinforced with channel or angle irons.
   b. Butt sections flush, end-to-end against similar section without bolts, nuts, or cover plates causing interference.
   c. Removable top cover plates and bottom cover plates.
   d. Removable plates on end panels for future bus extension.
3. Section Mounting: Removable formed-steel channel sills and lifting angles to meet specified seismic requirements.
4. Horizontal Wiring Compartments: Accessible from front, full width, top and bottom.
5. Vertical Wiring Compartment: Full height, isolated from unit starters with separate hinged door and tie supports. No terminal blocks allowed in vertical wireway compartment.
6. Unit Compartment: Individual compartments separated by steel barriers for each starter, feeder, or other unit capable of being wired from front without unit removal.
7. Compartment Doors: Separate hinged doors for each starter, feeder, or other unit.
8. Door Interlocking: Mechanically interlock starter and feeder doors so doors cannot be opened with unit energized. Provide defeater mechanism to allow intentional access and energizing at any time by qualified individual.
9. External disconnect handles with ON/OFF and trip positions showing, padlockable in OFF position with up to three-lock capability.
10. Cable Entrance: Main leads enter from bottom; control and feeder circuits enter from bottom.

C. Bus:

1. Horizontal Power Bus:
   a. Three-phase tin-plated, copper, entire width of control center, rated as indicated.
   b. Construct to allow future extension of additional sections.
   c. Pressure type solderless lugs for each incoming line cable.
   d. Isolated from top horizontal wireway.
2. Vertical Power Bus:
   a. Three-phase tin-plated, copper, full height of section, rated 300 amperes.
   b. Sandwich type bus insulation providing deadfront construction with starter units removed except for bus stab openings.
   c. Insulated and isolated barrier, complete with shutters.

3. Neutral Bus: None.
4. Ground Bus: Copper, tin-plated, rated 300 amperes, entire width of control center and in each vertical wireway.
5. Bus Bracing: 42,000 amperes rms symmetrical.

D. Motor Controller Unit:

1. Provide indicated individual components and control devices including pushbuttons, selector switches, indicating lights, control relays, time delay relays, and elapsed time .
2. Construction:
   a. Drawout combination type with stab connections for starters NEMA ICS, Size 5 and smaller.
   b. Bolt-on combination type with cable connection to riser for starters NEMA ICS, Size 6 and larger.
   c. Readily interchangeable with starters of similar size.
   d. Pull-apart unit control wiring terminal boards on all units.
3. Starters:
   a. NEMA ICS 18, standard rating, except none smaller than NEMA ICS, Size 1.
   b. Rating: Horsepower rated at 600 volt, CSA labeled for 42,000 amperes at 575 volts short circuit capacity with overload protection.
   c. Three-phase, nonreversing, unless specified otherwise.
   d. Disconnect Type: Motor circuit protector.
   e. Combination Full Voltage, Magnetic Starter:
      1) Control: As shown.
      2) Indicating Lights: As shown.
   f. Communications: None.
   g. Padlockable operating handle when de-energized with up to three-lock capability.
   h. Unit door interlocked to prevent opening when disconnect is in closed position.
   i. Mechanical interlocked to prevent placing disconnect in ON position when unit door is open.
   j. Minimum Dimensions: 12 inches high by full section width, less vertical wireway.
4. Disconnecting Device:
   a. As indicated.
   b. Padlockable in OPEN position.
5. Circuit Breaker:
   a. Meet requirements of NEMA AB 1 and UL 489.
   b. Molded case with manufacturer's recommended trip setting for maximum motor protection.
   c. Thermal-magnetic trip.

d. Tripping indicated by operating-handle position.
e. Interrupting capacity required for connection to system with short circuit capacity indicated.

6. Thermal Motor Overload Protection:
   a. Inverse-time-limit characteristic.
   b. Heater: Bimetallic overload, adjustable trip, or directly heated melting alloy, ratchet principle type element.
   c. Relay Trip: Standard, Class 20.
   d. Manual reset.
   e. Provide in each ungrounded phase.
   f. Mount within starter unit.
7. Ground Fault Protection: Where indicated and as specified in Paragraph Main Protective Device and Feeder Units, except provide instantaneous operation device.

E. Control Unit:

1. Disconnecting Device: Pull-apart terminal blocks capable of de-energizing external source control circuits in unit.
2. Control Devices: As indicated .
3. Control Wiring:
   a. Copper, 14 AWG, minimum.
   b. Permanent sleeve type markers with wire numbers applied to each end of wires.
   c. Terminate wires using insulated locking fork or ring type crimp terminals.
   d. Terminate current transformer leads on shorting type terminal blocks.

F. Incoming Line Terminal:

1. Construction: As specified in Paragraph Motor Controller Unit.
2. Incoming Service Feeder: Cable.

G. Main Protective Device and Feeder Unit:

1. Construction: As specified in Paragraph Motor Controller Unit.
2. Incoming Service Feeder: Individual conductors.
3. Static Trip Circuit Breaker:
   a. In accordance with NEMA AB 1 and UL 489.
   b. Main protective device.
   c. Insulated or molded case breakers with ambient insensitive solid-state trips and having current sensors and logic circuits integral in breaker frame.
   d. Solid-state current control with adjustable ampere setting, adjustable long-time delay, adjustable short-time trip and delay band, fixed or adjustable instantaneous trip, and adjustable ground fault trip and delay band.

e. Setting adjustments to be covered by a sealable, tamper-proof, transparent cover (insulated case breakers only) or by compartment door for other breakers).
f. Locate trip button on front cover of breaker to permit mechanical simulation overcurrent tripping for test purposes and to trip breaker quickly in emergency situation.

4. Moulded Case Circuit Breaker:
   a. In accordance with NEMA AB 1 and UL 489.
   b. Feeder protective device.
   c. Thermal-magnetic trip and interrupting capacity required for connection to system with short circuit capacity indicated.
   d. Indicate tripping by operating-handle position.
   e. Suitable for use with 75 degrees C wire at full NEC 75 degrees C ampacity.
5. Key Interlocking: Manufacturer's standard.

2.06 SOURCE QUALITY CONTROL

A. Factory Testing:

1. Applicable Standards: NEMA ICS 18, UL 845, and NEC Article 430, Part H.
2. Perform standard factory inspection and tests in accordance with NEMA requirements to verify components have been designed to specification, assembled in accordance with applicable standards, and each unit functions in accordance with electrical diagrams.
3. Actual operation shall be performed wherever possible. Otherwise, inspect and perform continuity checks.
4. Verify component devices operated correctly in circuits as shown on diagrams or as called for in Specifications.
5. Control Circuits and Devices:
   a. Energize circuit at rated voltage.
   b. Operate control devices.
   c. Perform continuity check.
6. Instruments, Meters, Protective Relays, and Equipment:
   a. Verify devices functioned by energizing potential to rated values with connection to devices made at outgoing terminal blocks.
   b. Verify protective relays operated for functional checks and trips manually initiated to verify functioning of operation for indicator and associated circuits.
7. Perform dielectric tests on primary circuits and equipment, except potential transformers. Tests shall be made phase-to-phase and phase to ground with 60-cycle test voltages applied for 1 second at 2,640 volts.
8. Verify equipment passed tests and inspection.
9. Provide standard factory inspection and test checklists and final certified and

signed test report.

PART 3. EXECUTION

3.01 INSTALLATION

A. Install equipment in accordance with NEMA ICS 2.3, ANSI C2, Submittals, and manufacturer's written instructions and recommendations.

B. Secure equipment to mounting pads with anchor bolts of sufficient size and number adequate for specified seismic conditions.

C. Install equipment plumb and in longitudinal alignment with pad or wall.

D. Coordinate terminal connections with installation of secondary feeders.

E. Grout mounting channels into floor or mounting pads.

F. Retighten current-carrying bolted connections and enclosure support framing and panels to manufacturer's recommendations.

3.02 CIRCUIT BREAKERS

A. Field adjust trip settings of motor starter magnetic-trip-only circuit breakers.

B. Adjust to approximately 11 times motor rated current.

C. Determine motor rated current from motor nameplate following installation.

3.03 OVERLOAD RELAY

A. Select and install overload relay heaters and switch settings after actual nameplate full-load current rating of motor has been determined.

3.04 MOTOR DATA

A. Provide typed, self-adhesive label attached inside each motor starter enclosure door displaying the following information:

1. Motor served by tag number and equipment name.
2. Nameplate horsepower.

3. Motor code letter.
4. Full load amperes.
5. Service factor.
6. Installed overload relay heater catalog number.

3.05 POWER FACTOR CORRECTION CAPACITOR

A. Provide suitable hangers or mounting brackets for wall mounting.

B. Mount power factor correction capacitors with blown fuse indictors facing away from the wall on which the unit is mounted.

3.06 MANUFACTURER'S SERVICES

A. Furnish manufacturer's representative in accordance with Section 01640, Manufacturer's Services, and Section 01810, Equipment Testing and Facility Startup, for the following services at jobsite or classroom as designated by City, for minimum person-days listed below, travel time excluded:

1. 1 person-days for installation assistance, and inspection of installation.
2. 2 person-days for functional and performance testing.
3. 2 person-day for training of City's personnel for each shift, in two trips.
   a. Number of Shifts: 2.

END OF SECTION

PART 1. GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this Section:

1. Institute of Electrical and Electronics Engineers (IEEE):
   a. C62.1, Surge Arresters for Alternating Current Power Circuits.
   b. C62.11, Standards for Metal-Oxide Surge Arrestors for AC Power Circuits.
2. National Electrical Contractor's Association (NECA): 407, Recommended Practice for Installing and Maintaining Panelboards.
3. National Electrical Manufacturers Association (NEMA):
   a. 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
   b. 289, Application Guide for Ground Fault Circuit Interrupters.
   c. AB 1, Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures.
   d. KS 1, Enclosed Switches
   e. LA 1, Surge Arrestors.
   f. PB 1, Panelboards.
   g. PB 1.1, General Instructions for Proper Installation, Operation and Maintenance of Panelboards Rated 600 Volts or Less.
4. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).
5. Underwriters Laboratories Inc. (UL):
   a. 67, Standard for Panelboards.
   b. 98, Standard for Enclosed and Dead-Front Switches.
   c. 486E, Standard for Equipment Wiring Terminals for use with Aluminum and/or Copper Conductors.
   d. 489, Standard for Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit Breaker Enclosures.
   e. 508, Standard for Industrial Control Equipment.
   f. 870, Wireways, Auxiliary Gutters and Associated Fittings.
   g. 943, Standard for Ground-Fault Circuit-Interrupters.

1.02 SUBMITTALS

A. Action Submittals:

1. Manufacturer's data sheets for each type of panelboard, protective device, accessory item, and component.
2. Manufacturer's shop drawings including dimensioned plan, section, and elevation for each panelboard type, enclosure, and general arrangement.
3. Tabulation of features for each panelboard to include the following:

a. Protective devices with factory settings.
b. Provisions for future protective devices.
c. Space for future protective devices.
d. Voltage, frequency, and phase ratings.
e. Enclosure type.
f. Bus and terminal bar configurations and current ratings.
g. Provisions for circuit terminations with wire range.
h. Short circuit current rating of assembled panelboard at system voltage. Features, characteristics, ratings, and factory settings of auxiliary components.

B. Informational Submittals: Manufacturer's recommended installation instructions.

1.03 QUALITY ASSURANCE

A. Listing and Labeling: Provide products specified in this Section that are listed and labeled as defined in NEC Article 100.

PART 2. PRODUCTS

2.01 MANUFACTURERS

A. Materials, equipment, and accessories specified in this section shall be products of:

1. Eaton/Cutler-Hammer.
2. General Electric Co.
3. Square D Co.

B. No "or-equal" or substitute products will be considered.

2.02 GENERAL

A. Provide low voltage panelboards for application at 600V or less in accordance with this Section

B. Provide equipment in accordance with NEMA PB 1, NFPA 70, and UL 67.

C. Wire Terminations:

1. Panelboard assemblies, including protective devices, shall be suitable for use with 75 degrees C or greater wire insulation systems at NEC 75 degrees C conductor ampacity.
2. In accordance with UL 486E.

D. Load Current Ratings:

1. Unless otherwise indicated, load current ratings for panelboard assemblies, including bus and circuit breakers, are noncontinuous as defined by NEC. Continuous ratings shall be 80 percent of noncontinuous rating.
2. Where indicated "continuous", "100 percent", etc., selected components and protective devices shall be rated for continuous load current at value shown.

E. Short Circuit Current Rating (SCCR): Integrated equipment short circuit rating for each panelboard assembly shall be no less than the following:

1. Minimum SCCR at 208Y/120 or 120/240 volts shall be 10,000amperes rms symmetrical.

F. Overcurrent Protective Devices:

1. In accordance with NEMA AB 1, NEMA KS 1, UL 98, and UL 489.
2. Protective devices shall be adapted to panelboard installation.
   a. Capable of device replacement without disturbing adjacent devices and without removing main bus.
   b. Spaces: Cover openings with easily removable cover.
3. Series-Connected Short Circuit Ratings: Devices shall be fully rated; series-connected ratings unacceptable

G. Circuit Breakers:

1. General: Thermal-magnetic unless otherwise indicated, quick-make, quick-break, molded case, of indicating type showing ON/OFF and TRIPPED positions of operating handle.
2. Noninterchangeable: In accordance with NEC.
3. Bus Connection: Bolt-on circuit breakers in all panelboards
4. Trip Mechanism:
   a. Individual permanent thermal and magnetic trip elements in each pole.
   b. Two and three pole, common trip.
   c. Automatically opens all poles when overcurrent occurs on one pole.
   d. Calibrated for 40 degrees C ambient, unless shown otherwise.
5. Unacceptable Substitution:
   a. Do not substitute single-pole circuit breakers with handle ties for multi-pole breakers.
   b. Do not use tandem or dual circuit breakers in normal single-pole spaces.
6. Ground Fault Circuit Interrupter (GFCI): Where indicated, equip breaker as specified above with ground fault sensor and rated to trip on 5-mA ground fault within 0.025 second (UL 943, Class A sensitivity, for protection of personnel).
   a. Ground fault sensor shall be rated same as circuit breaker.
   b. Push-to-test button.
   c. Reset button.

H. Enclosures:

1. Provide as specified in Section 16050, Basic Electrical Materials and Methods.
2. Material: Type 1, Type 3R, and Type 3S shall be code-gauge, hot-dip galvanized sheet steel with reinforced steel frame.
3. Finish: Rust inhibitor prime followed by manufacturer's standard gray baked enamel or lacquer.

I. Bus:

1. Material: Copper, full sized throughout length.
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.

J. Equipment Ground Terminal Bus: Copper with suitably sized provisions for termination of ground conductors, and bonded to box.

1. Provide individual mechanical termination points no less than the quantity of breaker pole positions.
2. Provide individual termination points.

K. Neutral Terminal Bus: Copper with suitably sized provisions for termination of neutral conductors, and isolated from box.

1. Provide individual mechanical termination points no less than the quantity of breaker pole positions.

2.03 LIGHTING AND APPLIANCE BRANCH CIRCUIT PANELBOARDS

A. Protective Device Locking: Furnish provisions for handle padlocking for main and subfeed devices; also provide for branch devices where indicated.

B. Multi-Section Panelboards: Where more than 42 poles are required or more than one section is otherwise indicated, provide multiple panelboards with separate fronts.

1. Not Used

C. NEMA 250 Type 1 Branch Panelboard Enclosure:

1. Not Used

2.04 POWER DISTRIBUTION PANELBOARDS

A. Not Used

PART 3. EXECUTION

3.01 GENERAL

A. Install in accordance with NECA 407, NEMA PB 1.1 and manufacturers' written installation instructions.

B. Install securely, plumb, in-line and square with walls.

C. Install top of cabinet trim78 inches above floor, unless otherwise shown. Install cabinet so tops of protective device operating handles are no more than 78 inches above the floor.

D. Ground Fault Protection: Install panelboard ground fault circuit interrupter devices in accordance with installation guidelines of NEMA 289.

E. Install filler plates in unused spaces.

F. Wiring in Panel Gutters: Train conductors neatly in groups; bundle, and wrap with nylon wire ties.

3.02 BRANCH CIRCUIT PANELBOARD

A. Mount panelboard in MCC as per drawings.

B. Provide typewritten circuit directory for each panelboard.

3.03 POWER DISTRIBUTION PANELBOARD

A. Not Used

3.04 SUPPLEMENTS

A. The supplements listed below, following "End of Section" are a part of this Specification.

1. Panelboard Schedules.

END OF SECTION

Bid Opportunity 839-2012	BRRMF L&YW AND PILOT BIOSOLIDS COMPOSTING	Page 1 of 1
REVISION 0	SECTION 16442-01 PANELBOARDS SCHEDULE	

Power Source:	XFMR-TR100		LPA						Location:	Mixing & Receiving Building
Feeder:	MCC								Voltage:	208/120V, 4 WIRE
BUILDING MECH/LIGHTING ITEMS - REV 1			Main Breaker:	100	A				Mounting:	Wall Mount
			Mains:	100	A					
DESCRIPTION	**LOAD**	**BKR**	**CCT**	**A**	**B**	**C**	**CCT**	**BKR**	**LOAD**	**DESCRIPTION**
Building Lighting	0.60	15A,1P	1	*			2	20A,1P	0.75	ASP Outdoor Lighting
Equipment Room Receptacles	0.25	15A,1P	3		*		4	15A,1P	0.19	Outdoor Receptacles **
Building Receptacles	0.25	15A,1P	5			*	6	15A,1P	1.50	Main Control Panel
Control Panel Power	0.25	15A,3P	7	*			8	40A, 2P	1.50	Irrigation Pump
Area Lighting ControlPanel	0.25	15A,1P	9		*		10		1.50	
SCADA Computer	0.25	15A,1P	11			*	12			
Building Exterior lights	0.25	15A,1P	13	*			14			
L& YW Area Lighting	0.50	15A,2P	15				16			Space
	0.50		17				18			Space
Space			19				20			Space
Space			21				22			Space
Space			23		*		24			Space

**** GFI CIRCUIT BREAKER**

* **TO LIGHTING CONTROL PANEL**

Phase A Total	3.35	kW	Panel Total	7.535	kW
Phase B Total	2.185	kW			
Phase C Total	2	kW		20.9	Est. Amps

PART 1. GENERAL

1.01 SUMMARY

A. Comply with Division 1 - General Requirements and Section 16050 - Basic Electrical Equipment.

1.02 REFERENCES

A. CSA C22.2 No. 0.4 Bonding and Grounding of Electrical Equipment (Protective Grounding).

B. CSA C22.2 No. 41 Grounding and Bonding Equipment.

C. IEEE No. 80 IEEE Guide for Safety in AC Substation Grounding.

D. IEEE No. 837 IEEE Standard for Qualifying Permanent Connections Used in Substation Grounding.

PART 2. PRODUCTS

2.01 MANUFACTURED UNITS

A. Comply with standards listed in 1.02, References.

B. Ground conductors: Concentric, stranded, soft drawn copper, insulated where required by Inspection Authorities.

C. Insulation: 600 volt rating, green colour.

D. Ground clamps: To accommodate system ground conductor and metallic pipe not suitable for thermit weld connections, GUV Series by Thomas & Betts Ltd., GAR-BU Series by Burndy Inc.

E. Compression connectors: Pure wrought copper material, prefilled with oxide inhibiting compound. Materials and tools by one manufacturer.

F. Mechanical connectors: Bronze, copper or brass construction with stainless steel hardware, sized for application, to CSA 22.2 No. 41.

G. Thermit weld connections: Exothermic process, compatible with the materials being interconnected, designed for the specific application and grounding conductor size. Cadweld by Erico Canada Inc.

PART 3. EXECUTION

3.01 INSTALLATION

A. Bond transformers, equipment bases and supporting frames, motor frames, panels, switchgear, metallic raceways, cable trays and metallic piping with the building ground bus located in the electrical room.

B. Bond instrumentation system separately from electrical distribution system and connect to building ground bus.

C. Thermit weld ground connections to flat metallic surfaces. Locate connections avoiding mechanical damage.

D. Bolt ground connection directly to steel using pressure connectors and 9 mm silicon bronze alloy bolts where welding is prohibited or impractical. Peen ends after installation. Drill maximum 12 mm diameter holes through steel members.

E. Clean grounding metal contact surface points of paint, rust and other detrimental materials. Lightly coat contact surfaces with oxide-preventing agent before bolting connection to steel member.

F. Protect grounding conductors and buses subject to mechanical damage with rigid aluminum conduit or guards grounded at both ends.

G. Connect to ground buses using mechanical clamp type connectors.

H. Bond metal enclosures and steel supports with stranded copper conductors.

I. Terminate ground conductors forming an integral part of cables to equipment ground studs. Where a stud is not provided, install a ground fitting without damaging the equipment.

J. Ground cable armour at both ends of single conductor cables carrying 425 A maximum. Ground single conductor cables carrying 425 A minimum, at one point only. Isolate exposed armour from conductive surfaces.

K. Ground instrumentation cable drain wires at one end only. Bond wires together where two or more drain wires are supplied in one cable.

L. Install 25 mm rigid PVC conduit sleeves where ground conductors penetrate concrete walls, floors, foundations and similar locations. Seal sleeves installed in walls or floors below grade and make water-tight after installation of ground conductor.

3.02 FIELD QUALITY CONTROL

A. Test ground continuity and resistance prior to energizing electrical systems.

B. Test grounding system efficiency for compliance with Electrical Safety Code and Supply Authority requirements. Verify ohmic resistance values are not exceeded.

END OF SECTION

PART 1. GENERAL

1.01 SUMMARY

A. Comply with Division 1 - General Requirements and Section 16050 - Basic Electrical Materials.

B. Products installed, but not supplied under the Work of this section: Variable frequency drive supplied as part of driven equipment package. Refer to other Divisions and Sections of specification.

1.02 REFERENCES

A. IEEE 519 Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems.

1.03 DESIGN REQUIREMENTS

A. Continuous duty, solid state, modular, adjustable variable frequency drive (VFD) system suitable for operation on plant electrical power system, controlled locally or remotely.

B. Obtain motor data and coordinate characteristics of driven equipment with VFD system.

C. Design drive system against:

1. Premature breakdown of motor insulation,
2. Higher than rated motor temperature rise as dictated by motor manufacturer, under intended operating speed and load range.

1.04 PERFORMANCE REQUIREMENTS

A. Environmental conditions: Ambient operating temperature range -40°C to 40°C, humidity range 20% to 90% RH non-condensing, altitude 1000 m maximum above sea level.

B. VFD system: Pulse width modulating (PWM) technology, 600 V (+10%, -10%), 3 phase, 60 Hz (±3%) input 3 phase, adjustable frequency and voltage output, suitable for controlling speed of standard AC squirrel cage induction motor.

C. Voltage/Frequency ratio (V/Hz): Vary output voltage proportionally with output frequency to maintain a constant V/Hz value over output range of 0.5 to 60 Hz. Output voltage to remain constant above 60 Hz.

D. Controller: Include power conversion components, power control logic devices and regulator circuitry. Incorporate into regulator, microprocessor technology for control of power semi-conductors.

E. Motor Speed Control: Stable throughout speed range, without cogging.

F. Rating: 100% continuous motor current under ambient conditions indicated and 150% rated motor current for one minute when applied to constant or high starting torque loads.

G. Displacement power factor: 0.93 minimum lagging over entire speed and load range.

H. Control circuitry ride-through capability: 16 milliseconds minimum on complete power loss.

I. Voltage Distortion Factor: As defined by IEEE 519, 5% maximum at the input terminals. Harmonic analysis based on available symmetrical short circuit current of 22000 A at 600 V at input to VFD.

J. Line notching: Notching area as defined by IEEE 519, 22800 V microseconds maximum with available short circuit of 22000A at 600 V. Notch depth, 10% maximum of normal peak line-to-neutral voltage.

K. Drive efficiency: 93% minimum on drives rated 37 kW or less and 95% minimum on drives rated greater than 37 kW.

L. Input current harmonics: 20% maximum for any individual current harmonic and 30% maximum total current harmonics at rectifier input, with balanced and unbalanced line voltage, under any load condition.

M. Output: Output frequency regulation within ±1% and output current waveform close to sine wave such that motor rating, excluding service factor, is not reduced by more than 5%.

N. Motor: Furnish VFD to match motor and driven equipment characteristics. Refer to Section 16220 - AC Induction Motors, for motor requirements. Confirm motor details with motor manufacturer.

O. Internal components, including printed circuit boards: corrosion protected.

P. Design drive to withstand without damage, the following conditions:

1. Phase-to-phase output short circuit.
2. Phase-to-ground output short circuit without utilizing an isolation transformer.
3. Application of stationary, reverse or forward rotating motor while the drive is

starting or while inadvertently running open circuit.
4. Momentary loss of line voltage, whether partial or complete.
5. Damage to DC bus soft charging circuitry by internal short circuit.

Q. Motor feeder: Wire in conduit .

R. Resetting after a fault: By reset input and or by re-issuing the Run command. Resetting by removing drive input power not acceptable.

S. Restart after a power outage or low voltage condition: Automatic with ten second delay when power returns to normal, if run command is maintained.

1.05 SUBMITTALS

A. Submit shop drawings with the following:

1. Detail specific electrical performance characteristics for each drive.
2. Detail layout, enclosure, cooling requirements and similar items.
3. Include values of notching and distortion factors at 600 V input to drive. If additional filtering is required, state notching and distortion factors with and without filtering.

B. Submit operation and maintenance manual with detailed records of start-up procedure, Site calibration settings and adjustments in typewritten tabular form. Report voltage and current values at intermediate operating points.

1.06 QUALITY ASSURANCE

A. Inspect and test components and sub-assemblies for conformance to manufacturer's engineering and quality assurance specifications.

B. Test printed circuit boards for minimum 20 hours while heat cycled to maximum temperature of 55°C.

C. Operate power sections under worst case conditions minimum of 12 hours and operate with motors 6 hours minimum.

D. Test drive with motor before shipment to assure proper operation within the driven equipment speed range. Test and verify operating, alarm and interlock conditions.

PART 2. PRODUCTS

2.01 MANUFACTURERS

A. To Match MCC manufacturer.

2.02 MANUFACTURED UNITS

A. Enclosure

1. VFDs to be mounted in MCC.

B. Primary Filters and Surge Protection:

1. Filter circuits and surge suppressors: to protect inverter from AC line disturbances including 5000 V, 120 joules, maximum voltage spikes. Filters to prevent VFD from causing line voltage disturbances on plant distribution system.
2. Furnish input and output line reactors.

C. Radio Frequency Suppression:

1. Suppress generation of radio frequencies.

D. Primary Disconnect Device:

1. Main power disconnecting device: Moulded Case circuit breaker type, rated for full load current of drive, and capable of closing onto an available system fault current of 42000 A symmetrical.
2. Breaker handle: Operable from outside without opening cubicle doors, mechanically interlocked to prevent door from being opened with circuit breaker in ON position.

E. Control Transformer:

1. Control transformer: Dry type, fused primary and secondary windings, sized for 125% of maximum system control circuit requirements, including external circuits.
2. Secondary voltage: 120 V, 60 Hz.

F. Operator Controls and Interlocks:

1. Speed control in Auto (PLC) mode: Remote 4-20 mA DC signal.
2. Run input: 120 VAC, 2A dry contact.
3. Fault Condition Input: 120 VAC, 2A dry external Fault contact to shut down VFD.
4. Surge suppressor: On relay coils.

5. General purpose relays: Heavy duty, industrial, EEMAC rated, electrically held, 120 V, 60 Hz, 10 A, 120 V AC convertible contacts, Type P by Allen-Bradley Canada Ltd.
6. Remote indication of VFD Fault status: Isolated, separate contacts (1 NO, 1 NC).
7. Remote indication of Motor Running status: Isolated, separate contacts (1 NO, 1 NC).
8. Remote indication of output speed, isolated 4-20 mA signal.
9. Remote indication of MANUAL/OFF/AUTO selection status (1 NO, 1 NC).
10. Remote indication of LOCAL/REMOTE speed control selection status.
11. Solid state programming and diagnostic unit: Door mounted.
12. Door mounted controls and indicators, heavy duty, oil tight design:
    a. MANUAL/OFF/AUTO (PLC) selection,
    b. LOCAL/REMOTE (PLC) speed control selection,
    c. MOTOR STOP/START operation,
    d. Manual speed control, 0-100% scale,
    e. Speed indication, 0 -100% scale,
    f. Elapsed run time indication (hourly),
    g. Output current indication, 0-125% scale.
13. Door mounted indicator lights: Push-to-test type with LED lamps, indicating Power On (green), VFD Operation (red), Equipment Fault (amber), [In Bypass Mode (blue)].
14. Internal adjustment features:
    a. Active current limit adjustment, 50-100% range,
    b. Maximum frequency adjustment, 50-100% range,
    c. Minimum frequency adjustment, 0-100% range,
    d. Acceleration ramp rate adjustment, 3-200 seconds,
    e. Deceleration ramp rate adjustment, 3-200 seconds,
    f. Slip compensation, minimum range 5% of maximum frequency, no load to full load,
    g. IR compensation or boost, minimum range 30 VAC.
15. Isolated output signals, 4-20 mA, for remote readouts of output frequency and total power.
16. Main logic PCB: Adjustment and test points at ground potential.

G. Alarms and Safety Interlocks

1. Shut down without damage under the following conditions: (precise limits to be specified and documented by VFD manufacturer)
    a. Low AC input voltage. Indirect sensing of line voltage via DC bus not acceptable,
    b. Loss of input phase,
    c. High DC bus voltage,
    d. Low DC bus voltage,
    e. High peak DC bus or output current,

f. Drive over-temperature,
g. External fault contact operation,
h. Motor over-temperature relay operation.

2. Annunciators: LED type, visible on or through window in front door with the following real time annunciators:
   a. Incoming power.
   b. External interlock.
   c. DC bus charged.
   d. Drive over-temperature fault.
   e. Motor ground fault.
3. Fault memory retention circuit: with manual reset, annunciating the following system conditions:
   a. Line voltage fault.
   b. Over current fault.
   c. DC bus voltage fault.
   d. Logic fault.
4. Current limit: Control logic, accurate over entire speed range, to automatically reduce output frequency when load current exceeds adjusted current limit level.
5. Motor regeneration: Override circuit to limit regenerated energy.

H. Wiring

1. Internal wiring: Copper conductor, stranded, 600 V rated.
2. Wire identification: To correspond to wire numbers on schematic and control diagrams, Type Z wire marker by Wieland Electric Inc. on both ends. Colour coding is not acceptable.
3. Terminal blocks: Modular, for external wiring connections, 600 V, 25 A rating, DIN rail mounted. Label each terminal with same designation as connecting wire.
4. Group terminal blocks according to voltage or signal level and function. Allow 150 mm space between rows of terminals blocks. Install two conductors per block maximum.
5. Barriers: Covering exposed terminals and terminal blocks against inadvertent contact.
6. Warning labels: Lamacoid with 3 mm white letters on red background, on front of compartments where multiple power sources are present.
7. Lay-in duct: For wire groupings of six conductors or more. Acceptable Manufacturer: Panduit Canada. For smaller runs, use plastic tie wrap and clips.

I. Identification

1. Equipment identification: See Section 16010.
2. Nameplates: For face-mounted components.
3. Identify interior sub-assemblies compartments with lamacoid labels.
4. Warning nameplates: Lamacoid, 5 mm white lettering on red background, indicating presence of live circuit when VFD is in normal or bypass mode.

Mount on access doors and internal compartment doors or barriers.

PART 3. EXECUTION

3.01 COORDINATION

A. Coordinate characteristics and integration of variable frequency drive units with manufacturer of motors and driven equipment supplied under this Contract, other contracts or where existing.

3.02 FIELD QUALITY ASSURANCE

A. Carry out tests recommended by the manufacturer.

B. Verify voltage distortion and line notching factors do not exceed limits specified.

C. Submit report by testing organization, sealed by a Professional Engineer, verifying measured voltage distortion and line notching factors comply with specified requirements.

3.03 INSTALLATION

A. Install equipment in MCC as indicated.

3.04 MANUFACTURER'S SERVICES

A. Furnish manufacturer's representative in accordance with Section 01640, Manufacturer's Services for the following services at jobsite or classroom as designated by the City for the minimum person-days listed below, travel time excluded:

1. 2 person-days for assistance in setting up control system.
2. 2 person-days for start-up and to ensure trouble-free operation of the system.
3. 2 person-days per shift, in two trips to train City's staff in aspects of VFD operation, maintenance and start-up procedures.
   a. Number of shifts: 2.

END OF SECTION

PART 1. GENERAL

1.01 SUMMARY

A. Comply with Division 1 - General Requirements and Section 16050 - Basic Electrical Materials.

B. Comply with Section 16120 - Wiring Systems.

1.02 REFERENCES

A. ANSI/ISA-S5.1-1984 Instrumentation Symbols and Identification.

B. ANSI/ISA-S5.4-1976 (Revised 1989) Instrument Loop Diagrams.

C. ISA-S20-1981 Specification Forms for Process Measurement and Control Instruments, Primary Elements and Control Valves.

1.03 DESIGN REQUIREMENTS

A. The Specifications and Drawings have been developed on a conceptual basis. Provide devices, components and accessory items necessary for the operation of the instrumentation and control systems.

B. All electrical equipment/components shall bear the approval of the Canadian Standards Association or another accredited certification organization by the Standards Council of Canada. Where approval is not available, Vendor shall secure approval by contacting:

Manitoba Department of Labour
Mechanical & Engineering Branch
500-401 York Avenue, Winnipeg, Manitoba, Canada R3C 0P8
TEL: (204) 945-3373 FAX: (204)948-2308
Attention: Electrical Inspector

C. Allow 20% spare PLC I/O points for each signal type.

1.04 SUBMITTALS

A. Minimum of twelve (12) weeks before commencement of Work, submit the following:

1. Instrument data sheets, conforming to ISA-S20.
2. Descriptive literature.
3. Manufacturer’s installation diagrams for field-mounted equipment.
4. Mounting and piping drawings for field-mounted equipment.

B. Minimum of eight (8) weeks before commencement of Work, submit the following:

1. Control schematics showing the connections at each device and wiring or cabling between devices. Indicate types of loads, switches, transducers and power supplies such as motors, relays, lights, indicators, level switches, hand switches, isolators, signal selectors, dedicated 24 VDC power supplies, etc. Number and identify each component circuit and terminal.
2. Instrument panel layout drawings.
3. Instrument panel wiring diagrams.
4. PLC I/O rack layout. Drawings to depict actual rack layout showing points complete with ISA tags and function description.

C. To consider the Work complete, submit the following:

1. Final, as-constructed data sheets.
2. Maintenance manuals.
3. A list of recommended spare parts including the make, model number, suggested quantity, cost, and required lead time of each part.
4. Instrument calibration sheets. A sample calibration sheet is included at the end of this Section.

1.05 PROGRAMMING

A. Custom application software of Programmable Logic Controller (PLC).

B. Custom application software of Programmable HMI Computer.

1.06 DELIVERY OF EQUIPMENT

A. Make the following arrangements:

1. For the PLC, HMI Computer and associated hardware and software (equipment), expedite shop drawings with no exceptions.
2. In construction schedule state the PLC based control panel and HMI Computer equipment delivery date.
3. When directed, pick up the equipment and deliver to Site for installation or storage.

1.07 DEMONSTRATIONS AND VALIDATION

A. When the installation and calibration of instruments has been completed, and equipment has been thoroughly tested, demonstrate and prove the accuracy

and functional ability of each instrument, monitoring and control loop and the PLC system.

B. Demonstrate the maintenance and trouble-shooting procedures developed and prescribed by the manufacturer of each device.

C. During Demonstrations, provide the following services:

1. Demonstrate that the systems function as specified under each mode and set of conditions which are possible for the instrumentation, control equipment, process, process equipment and plant.
2. Demonstrate that the control logic responds and controls the process efficiently.

PART 2. PRODUCTS

2.01 GENERAL

A. Unless otherwise noted, supply instruments having linear, 4-20 mA, live-zero, output signals.

B. Unless otherwise noted, supply field-mounted instruments with CSA 4X housings.

C. Available main power will be at a nominal 120 V AC.

D. Supply field-mounted indicators calibrated in engineering units.

2.02 MANUFACTURED UNITS

A. ASP Temperature:

1. ASP Transmitter
   a. Remoted from sensor.
   b. Compatible with 3-wire Pt1000 sensor.
   c. 4-20 mA isolated output, linear with temperature.
   d. Suitable for 24 VDC power supply.
   e. Ambient temperature range -25 to 85°C.
2. ASP Temperature Sensor Assembly
   a. 3-wire PT1000 RTD sensor.
   b. 316 stainless steel thermowell.
   c. 25 mm NPT process connection.

Tag Numbers: TE/TT-101A, TE/TT-101B, TE/TT-102A, TE/TT-102B, TE/TT-103A, TE/TT-103B, TE/TT-104A, TE/TT-104B

B. Duct Temperature:

1. Duct Temperature Transmitter
   a. Compatible with 3-wire Pt1000 sensor.
   b. 4-20 mA isolated output, linear with temperature.
   c. Suitable for 24 VDC power supply.
   d. Ambient temperature range -25 to 85°C.
2. Duct Temperature Sensor Assembly
   a. 3-wire Pt1000 RTD sensor.
   b. 316 stainless steel thermowell.
   c. 25 mm NPT process connection.

Tag Numbers: TE/TT-110, TE/TT-120, TE/TT-130

C. Pressure Transmitter:

1. To monitor header piping and fan discharge pressures as per P&ID.
2. CSA 4.
3. 4-20mA output to PLC.

Tag Numbers: PE/PIT-110, PE/PIT-120, PE/PIT-130

D. Programmable Controller

1. As per Section 13390 Package Control Systems.

E. PC based HMI computer

1. As per Section 13390 Package Control Systems.

F. Leachate Tank High Level Switch (LSH-100)

1. Provide a single point level switch with 304SS wetted parts with carbon steel connection
   a. BABBITT INTERNATIONAL, Inc. model MLS-4EX 1 4C with design options to suit the actual tank volume and dimensions such that the "High Level" alarm is set at a 30 m^3 level in the tank.
2. Provide a remote high level Hi-Vis warning light (LAH-100) to indicate a High Level Alarm in the tank as per drawings.

2.03 FABRICATION

A. Instrument Panels: Comply with Section 16991 - Control Panels.

B. Schedule of Instrument Panels

Tag Numbers: CP-100

PART 3. EXECUTION

3.01 GENERAL

A. Locate field-mounted indicators and gauges to be clearly visible from normal walkways.

B. Protect each instrument circuit by means of a panel-mounted, terminal block-type, overcurrent-interrupting device.

C. Comply with Section 16050 - Basic Electrical Materials.

3.02 EXAMINATION

A. Before proceeding with the Work, report construction defects which will affect the Work of this Section. Proceed only when defects have been corrected.

3.03 INSTALLATION

A. Install instrumentation, control devices, and accessories necessary for operation of the system.

B. For each device, follow manufacturers' instructions for installation and connection. Meet grounding, power supply, air supply and physical requirements.

C. Provide 30 mm diameter stainless steel identification tags with punched markings for each field-mounted device. Permanently attach tags to devices with stainless steel lightweight chain.

D. Install equipment per manufacturer's recommendations.

3.04 FIELD QUALITY CONTROL

A. Calibrate instruments on Site. Follow the standards of calibration prescribed by the manufacturer of each instrument.

B. Supply and use calibration equipment at least three times as accurate as the instrument being calibrated. Submit calibration equipment test data.

C. Engage manufacturers' representatives to inspect equipment installation and to supervise the control system start-up.

D. Test and adjust each device and verify its operation in conjunction with related equipment in the same control loop and in the overall system.

E. Ensure that wires connecting field- and panel-mounted equipment to programmable logic controller (PLC) input and output modules are correctly terminated.

1. For all input and output points, perform a complete continuity test including intermediate terminations.
2. For digital input points, separately test the operation of each signal-generating device.
3. For digital output points, separately test the operation of each signal-receiving device.
4. For analog input points, separately test the operation of each signal-transmitting device.
5. For analog output points, separately test the operation of each controlled device.

F. At least two weeks before commissioning is to begin, submit three copies of a formal Input/Output Test Report to the Contract Administrator to review. A sample form is included with this Section.

G. Complete the first 3 columns of the Input/Output Test Report using an up-to-date version of a popular spreadsheet software package.

H. Treat the submission of the Input/Output Test Report as an assurance that wiring, connections and terminations have been thoroughly checked.

3.05 DEMONSTRATION

A. Demonstrate the accuracy and functional ability of each device, each monitoring and control loop, and the overall system.

B. Demonstrate the maintenance and trouble-shooting procedures developed and prescribed by the manufacturer of each device.

3.06 INSTRUMENT SUMMARY

A. The instrument summary lists the instruments, devices and Work of this Section.

B. The instruments and devices listed should be used in conjunction with the Process & Instrumentation Diagrams and the Schematic Control Diagrams.

C. The figures that appear under the column “RANGE/SET POINT” in the instrument summary indicate calibrated process ranges for the transmitters,

scales for the gauges, the indicators or indicating controllers, and adjustable ranges/set points for the switches.

3.07 SUPPLEMENTS

A. The following documents provided after End of Section for part of this specification:

Supplement 1 - Instrument Summary
Supplement 2 - Sample Input/Output Test Report.
Supplement 3 - Sample Instrument Calibration Sheet.
Supplement 4- Sample Instrument Loop Check Sheet.

END OF SECTION

TAG NO.	DEVICE	SERVICE	RANGE/ SET POINT	UNITS	P&ID/ PLAN/ PANEL
TE/TIT-101A					A-602 CP-100
TE/TIT-101B					A-602 CP-100
TE/TIT-102A					A-602 CP-100
TE/TIT-102B					A-602 CP-100
TE/TIT-103A					A-602 CP-100
TE/TIT-103B					A-602 CP-100
TE/TIT-104A					A-602 CP-100
TE/TIT-104B					A-602 CP-100
TE/TIT-110					A-602 CP-100
TE/TIT-120					A-602 CP-100
TE/TIT-130					A-602 CP-100
PE/PIT-110					A-602 CP-100

TAG NO.	DEVICE	SERVICE	RANGE/ SET POINT	UNITS	P&ID/ PLAN/ PANEL
PE/PIT-120					A-602 CP-100
PE/PIT-130					A-602 CP-100
LSH-100	Leachate Tank High Level Switch				A-602 CP-100
LAH-100	Leachate Tank High Level Alarm Light				A-602
AAH-1A	Mixing System Alarm Light				A-601

PROJECT _____

Point	POINT TYPE	SERVICE DESCRIPTION	WIRING TEST	FUNCTION TEST
XXXX-XXXX	DI		DONE 94-06-05	DONE 94-06-06
	DO			
	AI			
	AO			

SHEET 01 OF XX

SIGNED _____ (CONTRACTOR'S TECHNICIAN)

SIGNED _____ (CONTRACTOR'S PROJECT MANAGER)

DATE _____

DATE _____

CONTRACT NUMBER:_____

TAG NUMBER: _____

MANUFACTURER: _____

MODEL NUMBER: _____

SERIAL NO: _____

PROCESS SERVICE: _____

_____

INPUT	OUTPUT	
0.0%	_____	_____
25.0%	_____	_____
50.0%	_____	_____
75.0%	_____	_____
100.0%	_____	_____

CALIBRATION EQUIPMENT USED: _____

_____

NOTES: _____

_____

TECHNICIAN: _____ DATE: _____

COMPANY: _____

WITNESS: _____ DATE: _____

CUSTOMER _____

LOCATION _____ CONTRACT NO. _____ DWG. _____

DESIGN AREA _____ LOOP _____

DATA SHEETS COMPLETED: YES [ ] NO [ ]

INSTALLATION APPROVED [ ] CONTINUITY TEST [ ]

POWER TEST [ ] LEAK TEST [ ] VALVE STROKED [ ]

CONTROLLER SET TO: _____ ACTION

_____ GAIN / P.B.

_____ INTEGRAL

_____ DERIVATIVE

INTERLOCKS: _____

_____

LOOP LEFT FUNCTIONAL: YES [ ] NO [ ]

NOTES: _____

_____

_____

CHECKED BY : _____ DATE: _____

ACCEPTED BY: _____ DATE: _____

END OF SECTION

PART 1. GENERAL

1.01 SUMMARY

A. Comply with Division 1 - General Requirements and Section 16050 - Basic Electrical Equipment.

1.02 SUBMITTALS

A. Submit shop drawings of control panels and components showing dimensioned internal and external layouts, terminal block arrangements, construction details, material of construction and complete component Bills of Material.

B. Submit prior to panel delivery, complete wiring diagrams showing wiring between panel components and devices and panel terminal blocks, and between panel terminal blocks and remote (field) equipment. Identify components, conductors and terminal blocks, including remote terminal block identification.

C. Submit final record wiring diagrams at completion of project. Include changes made during field installation and start-up.

PART 2. PRODUCTS

2.01 MANUFACTURED UNITS

A. Control panels: Complete working system with instruments, meters, indicating lights, alarm annunciators, relays, contactors, switches auxiliary devices and similar items.

B. Arrangement of instruments and devices (face-mounted as well as rear-of-panel mounted): Allow sufficient access for maintenance.

C. Mounting Height: Indicating devices, controls and instruments between 1000 mm and 2000 mm above finished floor.

D. Side or back face mounted devices: On removable backplate. Direct mounted devices are not acceptable.

E. Nameplates: Removable, lamicoid, white letters on black background, to identify panel and equipment function, letters minimum 6 mm, fasten with stainless steel screws. Grind screws flush on inside of panel so no sharp edges protrude.

2.02 ENCLOSURE

A. Enclosure: Rigid, dead front, 2 mm steel sheet, CSA 4X, gasketted.

B. Swing Out Panel for mounting Touch Screen Computer complete with mounting plate designed for full 90° swing out to allow for access to back of PC unit.

C. Visible welding seams: Not acceptable.

D. Back plate: 2.7 mm steel sheet mounted on four 10 mm collar studs minimum with stainless steel hardware.

E. Doors: Removable, gasketted, continuous piano type hinges, lockable, keyed alike.

F. Print pocket: On inside of door, rigid, for storing manual, layout drawings and wiring diagrams.

G. Finish: Phosphatize, zinc chromate prime, baked enamel inside and outside, matte white interior and ANSI 61 grey exterior.

2.03 INTERNAL ASSEMBLY

A. Internal component and equipment mounting: On hinged sub-chasses, racks and back plates, arranged for ease of access and removal.

B. Pans and rails: For mounting terminal blocks, relays, contactors, wiring and similar devices.

C. Power supply disconnecting devices: To disconnect incoming power supply sources and individual feeder circuit supplies, moulded case circuit breakers, 10,000 A at 120 V AC interrupting capacity.

D. Instrument disconnecting devices: Moulded case circuit breakers, 3,000 A symmetrical interrupting capacity or fused terminal block for each instrument requiring 120 V supply.

E. Identification: Identify components, terminal blocks, power supplies, wiring and similar devices. Comply with Sections 16050 and 16120.

F. Warning signs: Identify sources of supply.

G. Wiring ducts: Maximum 50% fill, with snap-on cover, by Panduit Canada.

2.04 TERMINAL BLOCKS

A. Terminal blocks: Modular, rated 600 V 25 A minimum, tubular clamp type, 35 mm DIN rail mounted, individually removable, with removable insulating covers on exposed terminals carrying above 50 V, SAK Series by Weidmuller Ltd., UL Series by Phoenix Terminal Blocks Ltd., WK/4 Series by Wieland Electric Ltd. and Entrelec.

B. Mounting: 150 mm minimum wiring space between rows of terminal blocks.

C. Arrangement: Separate terminals and wiring by class of signal. Comply with Section 16120.

D. Spares: Minimum 20% spare terminals for each signal class.

2.05 INSTRUMENT GROUNDING

A. Instrument cable shields and equipment ground conductors connections: With screws and

clamp washers.

B. Comply with Section 16450.

2.06 OPERATOR DEVICES

A. EEMAC 4 panels: EEMAC 4X, Type 800H by Allen-Bradley Canada Ltd., Type SK by Square D Canada, Type PB1 or PB2 with rubber boot and legend plate gasket by Cutler-Hammer/Westinghouse.

B. EEMAC 4 panel indication lights: EEMAC 4X, integral transformer, push-to-test type with lens colours as indicated, Type SKT-1X9 by Square D Canada, Type 800H Allen-Bradley Canada Ltd.

C. Indicator lamps: Clustered LED type, replaceable from front.

2.07 CONTROL RELAYS

A. General purpose relays: Electrically held, enclosed, three 10 A, 24 VDC and 120 V AC as required, form C contacts minimum, screw terminal socket mount, with hold down clips, pilot light and push-to-test button.

B. Timing relays: Solid state, two 10 A, 120 V AC, form C contacts, screw terminal socket mount, knob adjustable timing.

C. Spares: Two spare general purpose and timing relays and two spare sockets of each type in each panel.

2.08 INSULATING BARRIERS

A. Barriers: Covering exposed terminals and terminal blocks against inadvertent contact.

B. Warning labels: Lamicoid with 3 mm white letters on red background, on front of compartments where multiple power sources are present.

2.09 INTERNAL WIRING

A. Comply with Section 16120.

B. Wiring type: Except shielded instrumentation wiring, copper, 600 V, single conductor, seven strands minimum, heat and flame-retardant type, RW90 or TEW insulation. #14 AWG minimum for control circuits and #12 AWG minimum for power circuits.

C. Wire colour coding: 120 VAC control circuits supplied from internal 120 VAC supply, red; 120 VAC control circuits supplied from external 120 VAC supply, yellow; 24 VDC control circuits, blue.

D. Instrumentation wiring: Comply with Section 16120.

E. Wiring devices on hinged doors or panels: Extra flexible, forty-nine strands minimum,

harnessed with nylon cable ties.

F. Wiring terminations: On terminal blocks. Splices and soldered connections are not permitted. Brace and support wiring.

G. Maximum number of conductors under one terminal: Two.

H. Wire markers: Identify wiring at ends with slip-on, plastic type markers, computer printed type by Critchley, Brady, or Shur-Code by Thomas & Betts Ltd., Z-Type by Wieland Electric Ltd.

I. Incoming cable supports: Clamp type.

J. Separation: Comply with Section 16120. Keep AC and DC conductors separate and do not group together in same wire duct or harness. In addition, separate DC conductors into low level and high level signal conductors. Supply separate wiring ducts for 120 V AC signals.

PART 3. EXECUTION

3.01 INSTALLATION

A. Provide control panels as indicated.

B. Mount panels as indicated in drawings.

END OF SECTION