

PART 1 - GENERAL

1.1 General Requirements

- .1 This section shall apply to and govern all sections of Division 16.

1.2 Scope

- .1 The contractor shall supply all items of labor, supervision, materials, equipment, tools, services and incidental items necessary to complete the Work of this contract to the full intent of the Drawings and Specifications. The Contractor shall note that all work will be carried out at an operating facility, and that the Work of this Contract must be coordinated with the City so as to minimize downtime and prevent conflict with facility operations.
- .2 For any instance where conflicts in the contract documents arise, the Contractor shall advise the Contract Administrator, and shall obtain clarification. For instances where clarification cannot be obtained or where the Contractor has not noticed discrepancies, the Contractor shall include the more stringent or costly option as part of his bid.
- .3 In general the work includes, but is not limited to, the following:
1. Mobilize and demobilize from site.
 2. Provide temporary facilities and services during construction. This includes requirements for temporary electrical power for mechanical, or civil works devices.
 3. Co-ordinate and provide all permits and approvals as required to complete the Work.
 4. Supply and install all materials required for the installation of a complete and operable facility, as shown on the Drawings and described in the Specifications. All Contractor furnished materials to be new, CSA approved, and as specified. Substitutes to the specified material shall be pre-approved by the Contract Administrator.
 5. Provide paint and labor to repair any damage to painted surfaces resulting from the work of this project.
 6. Repair all damage resulting from this Contract to associated facilities.
 7. Coordinate work with the appropriate utility, such as power shutdowns with Manitoba Hydro.

8. Coordinate work to ensure device locations do not interfere with each other. Review all Drawings and Specifications within the Bid Opportunity, including mechanical and civil works.
9. The Contract Administrator will perform periodic site observations. The Contractor shall assist the Contract Administrator by being present and on site during the site observations. During these observations, the Contract Administrator will record any deficiencies.
10. The existing waste water pumping station must remain in service at all times during the work. Allow City Personnel access to the facility and equipment at all times.
11. Co-ordinate all Work with the Contract Administrator so as to minimize interruptions to the facility operations. Plan all tie-in work so as to limit its duration to planned facility power shutdown periods.
12. Provide for necessary testing and quality control as called for in the Specifications.
13. Provide site cleanup on a weekly basis and upon project completion.
14. Provide samples, shop drawings, product data, and as-built drawings, as called for in specification 16010 and elsewhere in this document.
15. All work, installation and devices shall meet the latest edition of the Electrical Code, and shall be to the satisfaction of the Authority Having Jurisdiction.
16. Provide a detailed schedule of work plan, including shutdown dates, and length of time to perform work. The Facility is critical to the City of Winnipeg operations, and therefore, any power outage shall be planned in advance. Submit a work schedule detailing work to be performed, and include the duration of the power outage proposed to the City prior to any power shutdown. All shutdowns shall be approved in writing by the Contract Administrator.
17. Provide all work, materials, testing, etc. for a complete and working installation, and to meet the design intent as shown in the Drawings and Specifications.

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18. The Contractor shall provide and affix Arc Flash Stickers indicating Arc Flash energy levels and PPE requirements on the electrical equipment where arc flash energies are shown on the single line drawings.
- 1.3 Cost Breakdown .1 Upon notice of contract award, and as requested by the Contract Administrator, furnish a detailed price breakdown of tendered price to facilitate evaluation of progress payments.
- 1.4 Scope of Work .1 Electrical Demolition Work
- .1 Remove the existing 250kW, 347/600V generator, generator breaker, control panel, regulator, Robonic transfer switch and all associated devices and cabling as detailed in the Drawings and Specifications. Completely remove the existing equipment, crate it in boxes and hand over to the City.
- .2 Demolition of the existing generator building air compressor as detailed in the Drawings and Specifications. Demolition includes the removal of all associated power, devices, and control cabling, pneumatic piping, and pneumatic devices (pneumatic thermostat, pneumatic pressure switches, pneumatic solenoid, etc.) Un-used control selector switches, pilot lights, terminal blocks, etc may be tagged as "spare". Un-used cabling shall be completely removed.
- .3 Demolition of the existing generator ventilation fan control wiring necessary to make the required control modifications as detailed in the Drawings and Specifications.
- .2 Electrical Relocation Work
- .1 Relocate the existing panel A to location shown on the drawings. Extend branch circuit cabling and conduit as required.
- .2 Relocate the existing transformer to location shown on the drawing. Provide lamacoid for the transformer.
- .3 Relocate the existing duplex receptacle to location shown on the drawings in order to accommodate panel A relocation.
- .4 Confirm and relocate all devices which interfere with the locations of new or other relocated devices

on the plans. For example, any conduit or cable runs which will interfere with the installation of the transfer switch shall be relocated in order to accommodate the switch. Cable runs or other devices are not shown on the plans.

.3 General Electrical Work

- .1 Subcontract the services of J.R Stephenson to perform MCC modifications as per the electrical drawings.
- .2 Provide the Arc Flash stickers indicating energy levels, and PPE requirements on the MCC-1, and all other devices where levels are indicated on the details in the Drawings and Specifications.
- 3 Provide a new, emergency lighting battery pack, c/w two heads and receptacle.
- .4 Provide cabling as shown on the drawings.

.4 Generator Work

- .1 Provide a new 325 kW natural gas generator, battery charger, batteries, and all other necessary materials/equipment for a complete and fully functional system as per the Drawings and Specifications.
- .2 Provide a new 400A (rated 400A continuous) Automatic Transfer switch and all other necessary materials/equipment for a complete and fully functional system as per the Drawings and Specifications.
- .3 Provide all required wiring between the natural gas Genset and transfer switch and all other necessary materials/equipment for a complete and functional system as per the Drawings and Specifications.
- .4 The generator shall be installed and commissioned under the direction of a manufacturer licensed and certified technician.
- .5 Disconnect the temporary generator that is on-site. Remove temporary cabling and devices. Turn over the temporary generator and cabling to the City.

.5 Natural Gas Detection System

- .1 Provide natural gas detection system monitor, sensor, power supply and all other necessary materials/equipment for a complete and functional system as per the Drawings and Specifications.

- .6 Ventilation System Fan 204 and Dampers
 - .1 New dampers and actuators supplied and installed by Division 15. Division 16 – Electrical to supply and install all conduit, wire and connections, for a complete and functional system as per the Drawings and Specifications.

1.5 Codes and Standards

- .1 Within the text of these specifications, reference is made to the following standards:
 - EEMAC - Electrical and Electronic Manufacturers Association of Canada
 - CEMA - Canadian Electrical Manufacturers Association
 - NEMA - National Electrical Manufacturers Association
 - IEEE - Institute of Electrical and Electronic Engineers
 - IPCEA - Insulated Power Cable Engineers Association
 - CSA - Canadian Standards Association
 - ULC - Underwriters Laboratory of Canada
 - CEC – Canadian Electrical Code
- .2 Materials to carry CSA approval and conform with CEMA, EEMAC and ULC standards, or in the absence of these approvals, may be Department of Labour approved – where noted.
- .3 Equipment wiring and wiring devices shall meet the requirements of the Canadian Electrical Code – CSA C21.1-06, all current City of Winnipeg amendments and bylaws and Manitoba Electrical Code 2006 9th Edition.
- .4 Where equipment manufacturer has been identified in the tender, or an equal product approved, substitutions of other products will be subsequently permitted only where it can be shown that unusual or unforeseen circumstances will cause unacceptable delays in completion of the work. The onus will be on the Contractor to ensure that no delays are caused or additional costs incurred through the use of approved alternates or equals in accordance with B6.

1.6 Care, Operation and Start-up

- .1 Instruct the City's Operating and Maintenance personnel in the operation, care and maintenance of equipment.
- .2 Arrange for, and pay for services of manufacturer's factory service representative to supervise start-up of installation, check, adjust, balance and calibrate components as required.

- .3 Provide these services for such period, and for as many visits as necessary to put equipment in operation, and ensure that Operating and Maintenance personnel are conversant with all aspects of its care and operation.

1.7 Voltage Ratings

- .1 Operating voltages: to CAN3-C235-83.
- .2 Motors, generator, electric heating, control and distribution devices and equipment to operate satisfactorily at 60 Hz within normal operating limits established by above standard. Equipment to operate in the operating conditions established in above standard without damage to equipment.

1.8 Permits, Fees and Inspection

- .1 Submit to Local Authority having jurisdiction all the necessary number of Drawings and Specifications for examination and approval prior to commencement of work.
- .2 Pay associated fees.
- .3 The Contract Administrator will provide drawings and specifications required by Local Authority at no cost.
- .4 Notify the Contract Administrator of changes required by the Local Authority prior to making changes.
- .5 Furnish Certificates of Acceptance from authorities having jurisdiction on completion of work to the Contract Administrator.

1.9 Materials and Equipment

- .1 Equipment and material to be CSA certified. Where there is no alternative to supplying equipment which is not CSA certified, obtain special approval from the Department of Labor. A marking of approval by the Department of Labor shall be affixed to the device.
- .2 Factory assembled control panels and component assemblies shall be CSA certified.

1.10 Equipment and Controls

- .1 Provide all power and controls, cabling and devices as required for a full functioning, and complete system.
- .2 Control wiring and conduit is specified in Division 16.

1.11 Finishes

- .1 Shop finish metal enclosure surfaces by application of rust resistant primer inside and outside, and at least two coats of finish enamel.
 - .1 Paint outdoor electrical equipment "equipment green" finish to EEMAC Y1-1-1955.
 - .2 Paint indoor switchgear and distribution enclosures

light grey to EEMAC 2Y-1-1958.

- .2 Clean and touch up surfaces of shop-painted equipment scratched or marred during shipment or installation, to match original paint.
- .3 Clean and prime exposed non-galvanized hangers, racks and fastenings to prevent rusting.

1.12 Equipment
Identification

- .1 Identify electrical equipment with labels as follows:

- .1 Nameplates:

- .1 Lamacoid 3 mm thick plastic engraving sheet, white face, black core, mechanically attached with self tapping screws or rivets.

NAMEPLATE SIZES

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

- .2 Labels:

- .1 Embossed plastic labels with 6 mm high letters unless specified otherwise.
 - .3 Wording on labels to be approved by Contract Administrator prior to manufacture.
 - .4 Allow for average of twenty-five 35 letters per label.
 - .5 Identification to be English.
 - .6 Nameplates for terminal cabinets and junction boxes to indicate system and/or voltage characteristics.
 - .7 Disconnects, starters and contactors: indicate equipment being controlled and voltage.
 - .8 Terminal cabinets and pull boxes: indicate system and voltage.
 - .9 Transformers: indicate transformer label, capacity, primary and secondary voltages.
 - .10 Panels and MCCs: Indicate device tag, capacity in Amps, Voltage, phase

- .11 Nameplates shall be attached using self screws or rivets. Where a device cannot be riveted / screwed, it may be solidly chained to the device. The use of glue or tape to affix the nameplates to the piece of equipment is prohibited.

1.13 Wiring Identification

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

1.14 Conduit and Cable Identification

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

| | |
|-----------------------------|--------------|
| Prime | Auxiliary: |
| up to 250 V | yellow |
| up to 600 V | yellow green |
| Other communication Systems | gold blue |

- .4 All conductors shall be identified by coloured insulation and permanent markers at every terminal and accessible points throughout the entire run.

Conductors:

| | |
|------------------------------|------------------------------|
| Equipment Grounding | Green |
| Neutral Conductor | White |
| <u>347 / 600 Volt System</u> | <u>120 / 208 Volt System</u> |
| Phase A Red | Red |
| Phase B Black | Black |
| Phase C Blue | Blue |

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- 1.15 Wiring Terminations .1 Lugs, terminals, screws used for termination of wiring to be suitable for either copper or aluminum conductors.
- 1.16 Manufacturers and CSA Labels .1 Visible and legible after equipment is installed.
- 1.17 Warning Signs .1 As specified and to meet requirements of the Local Authority having jurisdiction and Consultant.
.2 Decal signs, minimum size 175 x 250 mm.
- 1.18 Mounting Heights .1 Mounting height of equipment is from finished floor to centreline of equipment unless specified or indicated otherwise.
.2 If mounting height of equipment is not specified or indicated, verify with Contract Administrator before proceeding with installation.
.3 Install electrical equipment at following heights unless indicated otherwise.
- 1.19 Workmanship .1 Workmanship shall be in accordance with well established practice and standards accepted and recognized by the trade.
.2 The consultant shall have the right to reject any item of work that does not conform to the Contract Documents and accepted standards of performance.
.3 Employ only tradesmen holding valid Provincial Trade Qualification certificates. Tradesmen shall perform only work that their certificate permits. Certificates shall be available for inspection by the Consultant. Apprentices will be allowed, but will be limited to one apprentice for every journeymen, and not all apprentices will be the same year.
- 1.20 Field Quality Control Specify exact nature, duration and timing of tests.
.1 Conduct and pay for testing of the generator. Testing shall be as per Section 16301.
.2 Furnish manufacturer's certificate or letter confirming that entire installation as it pertains to each system has been installed to manufacturer's instructions.
.3 Insulation resistance testing.
.1 Megger circuits, feeders and equipment up to 350 V with a 500 V instrument.
.2 Megger 350-600 V circuits, feeders and equipment with a 1000 V instrument.

- .3 Check resistance to ground before energizing.
- .4 Carry out tests in presence of Consultant where requested.
- .5 Provide instruments, meters, equipment and personnel required to conduct tests during and at conclusion of project.

- .4 Submit test results for Consultant's review. Include certified test result copies in O&M Manuals.

1.21 Work of Other Trades

- .1 Cooperate and coordinate the work specified in this section with the requirements of other units of work specified in other sections.
- .2 Refer to Mechanical and Structural drawings and specifications for electrical work in connection therewith. Where such work is included in this section of the specification, install such equipment as specified and in accordance with manufacturer's approved shop drawings.
- .3 The Electrical Subcontractor shall rough in and/or connect up all equipment requiring electrical service, as shown on Drawings or noted elsewhere in the Specifications.
- .4 Supply other trades with all necessary details, roughing-in drawings, etc. as required.
- .5 Check drawings of all trades to verify space and headroom limitations for work to be installed. Coordinate work with all trades and make changes to facilitate a satisfactory installation. Make no deviations, without prior approval of the Contract Administrator.

1.22 Site Examination

- .1 Visit the site before bidding and examine all local and existing conditions on which the work is dependent.
- .2 No consideration will be granted for any misunderstanding of work to be done resulting from failure to visit the site.
- .3 Provide for avoidance of damage and interference to existing work and rectify any damage due to work by this section.
- .4 Disconnect any existing equipment indicated to be re-used, rough-in in new position, and connect up ready for use. Removal and relocation of electrical equipment shall be completed by relevant section

1.23 Shop Drawings

- .1 Submit shop drawings in accordance with General Requirements for all materials.

- .2 Prior to submitting shop drawings for the Contract Administrator's review, the Contractor shall review all shop drawings to confirm their meeting all requirements of the project, and mark and sign his approval on the drawings.
- .3 Each shop drawing must be certified by the manufacturer and, as such, shall indicate that all product engineering has been performed to ensure that product will meet the requirements of the intended installation.
- .4 Whenever documents are provided in imperial and/or S.I. units, all performance and dimensional data shall be submitted in imperial and/or S.I. units. Where both dimensions are indicated, the other dimension will be in brackets.
- .5 Include wiring drawings on diagrams showing interconnection with work of other sections. For catalog cuts indicate specific product supplied.
- .6 Indicate details of construction, dimensions, capacities, weights and electrical performance characteristics of equipments or material. All shop drawings shall be identified with the project name.
- .7 Submit three copies of shop drawings for review to the Contract Administrator.

1.24 Record Drawings

- .1 Obtain a separate set of drawings and mark all as-built information as work progresses. Show all conduit and cable routing as well as circuitry.
- .2 Record drawings to show all field modifications.

1.25 Approved Equals / Alternates

- .1 The listing of manufacturer and his respective type or catalogue number as the basis of design, is to establish the construction features, sizes, quality, and accessories of an item of equipment in addition to the characteristics specified.
- .2 Approval of equivalent products will be granted on the basis of the manufacturer, and general design only. Such approval does not relieve the contractor from providing all necessary components and finishes as called for on the drawings or in the specifications to meet the functional requirement and intent of the design in accordance with B6.

1.26 Operation and
Maintenance Manuals

- .3 The Contractor shall make allowances in his bid for the cost of any associated changes made necessary by the selection of an approved product other than that named as the basis of designs. Additional costs due to the departure from equipment named shall be borne by the Contractor.
- .1 Provide operation and maintenance data for incorporation into an electrical maintenance manual as specified herein and in accordance with the General Conditions.
- .2 Include in operations and maintenance data a minimum of:
 - .1 Cover page including project name, year, name of owner and electrical consultant. Cover page shall be enclosed in a clear plastic cover.
 - .2 Index
 - .3 List of manufacturers and supplier for all items.
 - .4 Names, address and phone number of all local suppliers for items included in maintenance manual.
 - .5 Details of design elements, construction features, component function and maintenance requirements, to permit effective start-up operation, maintenance, repair, modification, extension and expansion of any portion or feature of installation.
 - .6 Stamped shop drawings (Approved only) - technical data, product data, supplemented by bulletins, component illustrations, exploded views, technical descriptions of items and parts lists. Advertising or sales literature not acceptable.
 - .7 Operating instructions for all systems.
 - .8 Certificate of Warrantee for the Electrical Installation (1 Year Warrantee for general electrical work).
 - .9 Certificate of Warrantee by the Supplier of the Generator (5 years of 1500 Op. Hours).
 - .10 Generator Load Test Reports.
 - .11 Certificate of Electrical Inspection by the A.H.J

- .3 Deliver to the Contract Administrator prior to the scheduled takeover date, three (3) sets of operation and maintenance manuals. Operation and maintenance data shall be contained within 76 mm thick, commercial quality, black, hard cover three "D-ring" binder. Binder shall be labelled directly on the front cover as well as the spine ("ELECTRICAL MAINTENANCE MANUAL – PROJECT NAME – YEAR"). Provide a total of three (3) copies of all manuals.
- .4 Index tabs shall be provided by specification section. Divider tab pages shall be laminated Mylar plastic with reinforced holes. Plastic tabs with typed insertions will not be accepted.

END OF SECTION 16010

PART 1 - GENERAL

- 1.1 References
- .1 Rigid metal conduit to: CSA C22.2 No. 45.
 - .2 Electrical metallic tubing to: CSA C22.2 No.83.
- 1.2 Location Of Conduit
- .1 Drawings do not indicate all conduit runs.
 - .2 All non-armoured cable shall be run in conduit.

PART 2 - PRODUCTS

- 2.1 Conduits
- .1 Rigid galvanized steel conduit.
 - .2 Electrical metallic tubing (EMT): with couplings with expanded ends.
- 2.2 Conduit Fastenings
- .1 One hole steel straps to secure surface conduits 50 mm and smaller. Two hole steel straps for conduits larger than 50 mm.
 - .2 Channel type supports for two or more conduits at 1.4 m on center, or as per the CEC.
- 2.3 Conduit Fittings
- .1 Fittings: manufactured for use with conduit specified. Coating: same as conduit.
 - .2 Factory "ells" where 90 degree bends are required for 27 mm and larger conduits.
 - .3 Watertight connectors and couplings shall be used for all EMT conduit runs. **Set-screws are not acceptable.**
- 2.4 Fish Cord
- .1 Polypropylene.

PART 3 - EXECUTION

- 3.1 Installation
- .1 All conduit to be surface mounted, or shall be run on cantruss hanger supports, unless noted otherwise or necessary due to specific equipment location.
 - .2 Install conduits to conserve headroom in exposed locations and cause minimum interference in spaces through which they pass.
 - .3 Cut all conduits square and ream to remove sharp edges and burrs.
 - .4 Use rigid galvanized steel threaded conduit as specifically noted on drawings.

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- .5 Use EMT Conduit where specifically noted on the drawings.
 - .6 Minimum conduit size: 21 mm
 - .7 Bend conduit cold. Replace conduit if kinked or flattened more than 1/10th of its original diameter.
 - .8 Mechanically bend conduit over 21 mm dia.
 - .9 Field threads on rigid conduit must be of sufficient length to draw conduits up tight.
 - .10 Install fish cord in empty conduits.
 - .11 Where conduits become blocked, remove and replace blocked section. Do not use liquids to clean out conduits.
 - .12 Dry conduits out before installing wire.
 - .13 Site determine location of fire rated walls and penetrations of those walls shall be sealed using an approved fire stop material rated to suit wall fire rating. Common penetration space with other services where possible. Minimize number of penetrations.
 - .14 All conduits crossing building expansion joints shall have conduit expansion fittings to suit type of conduit used, and shall be Crouse Hinds, Scepter or approved equal in accordance with B6.
 - .15 Seal conduits with duct seal where conduits are run between heated and unheated areas.
 - .16 Provide necessary flashing and pitch pockets making water tight joints where conduit passes through roof, walls or water tight membranes.
 - .17 Provide conduit fittings, pullboxes and junction boxes where necessary.
 - .18 Swab out conduit and thoroughly clean internally before wires and cables are pulled.
 - .19 Ensure electrical continuity in all metallic conduit systems.
 - .20 Run parallel or perpendicular to building lines.

3.2 Surface Conduits

- .1 Group conduits wherever possible.
- .2 Do not pass conduits through structural members except with the permission of the structural engineer.
- .3 Do not locate conduits less than 75 mm parallel to steam or hot water lines with minimum of 25 mm at crossovers.

END OF SECTION 16111

PART 1 - GENERAL

- 1.1 References .1 CSA C22.2 No.0.3-M1985 Test Methods for Electrical Wires and Cables.

PART 2 - PRODUCTS

- 2.1 Building Wires .1 Conductors: stranded for all sizes. Minimum size: 12 AWG except where noted on drawings.
.2 Copper conductors: size as indicated, with 1000 V insulation of chemically cross-linked thermosetting polyethylene material rated RW90.
- 2.2 Control Cables .1 Type LVT: soft annealed copper conductors, #16 AWG twisted shielded, control, and instrumentation cable (CIC) run in conduit. Complete with thermoplastic insulation (300V rated), outer covering of thermoplastic jacket.

PART 3 - EXECUTION

- 3.1 Installation of Wires .1 Install wiring in conduit systems in accordance with Section 16111.
- 3.2 Colour coding and Numbering .1 Colour code all power distribution conductors at both ends throughout facility.
.2 Same colour for same phase throughout, by insulation colour or permanently applied colour banding at all distribution centres, panels and outlet boxes.
.3 Colour coding to be in accordance with C.E.C and as follows:
- | | |
|-------------------------------|-------------------------------------|
| Equipment Grounding Conductor | - green or green with yellow tracer |
| Neutral conductor | - white |
| 1 Phase, 3 wire | - red, black and white |
| 3 Phase | - red (A), black (B), blue (C) |
- See also Section 16010

- .4 All control conductors shall be numbered at both ends using wrap-on self-adhesive labels. Labels shall be included at both ends, indicating the cable tag (as per the drawings) and the status of the use of the conductors ("spare", etc).

END OF SECTION 16120

PART 1 - GENERAL

- 1.1 Shop Drawings and Product Data .1 Submit shop drawings and product data for cabinets in accordance with Section 16010.

PART 2 - PRODUCTS

- 2.1 Junction and Pull Boxes .1 EEMAC Type 1 or 2, general indoor use.
- 2.2 Cabinets .1 EEMAC Type 1 or 2, general indoor use.

PART 3 - EXECUTION

- 3.1 Junction, Pull Boxes and Cabinets Installation .1 Install pull boxes in inconspicuous but accessible locations.
- .2 Mount cabinets with top not higher than 2 m above finished floor.
- 3.2 Identification 1 Provide equipment identification in accordance with Section 16010 - Electrical - General Provisions.
- .2 Install size 2 identification labels indicating system name voltage and phase.

END OF SECTION 16131

PART 1 - GENERAL

- 1.1 Work Included .1 Provide a complete system of boxes for the installation of wiring equipment.
- 1.2 References .1 CSA C22.1 Canadian Electrical Code, Part 1.

PART 2 - PRODUCTS

- 2.1 Outlet and Conduit Boxes General
- .1 Size boxes in accordance with CSA C22.1.
- .2 102 mm square or larger outlet boxes as required for special devices.
- .3 Blank cover plates for boxes without wiring devices.
- 2.2 Conduit Boxes .1 Cast FS or FD ferrous alloy boxes with factory-threaded hubs and mounting feet for surface wiring.
- 2.3 Fittings - General
- .1 Bushing and connectors with nylon insulated throats.
- .2 Conduit outlet bodies for conduit up to 32 mm and pull boxes for larger conduits.

PART 3 - EXECUTION

- 3.1 Installation
- .1 Support boxes independently of connecting conduits.
- .2 Fill boxes with paper, sponges or foam or similar approved material to prevent entry of debris during construction. Remove upon completion of work.
- .3 Provide correct size of openings in boxes for conduit, connections. Reducing washers are not allowed.
- .4 Do not distort boxes during installation. If boxes are distorted, replace with new boxes.
- .5 Do not use sectional boxes.
- .6 Provide boxes sized as required by the Canadian Electrical Code.
- .7 Primary bushings in termination box for cable connection.

END OF SECTION 16132

PART 1 - GENERAL

- 1.1 Related Sections .1 Section 16301 – Automatic Load Transfer Equipment.
- 1.2 References .1 ANSI/NEMA MG1-1978, Motors and Generators.
.2 CSA C282 – Emergency Electrical Power Supply for Buildings
- 1.3 Description of System .1 Generating system consists of:
.1 Natural Gas engine.
.2 Alternator.
.3 Control panel.
.4 Breaker (400A, LSI Trip)
.5 Automatic transfer equipment.
.6 Battery charger and battery.
.7 Automatic engine room ventilation system (automatic control of damper motors, etc.).
.8 Fuel supply system.
.9 Anti-Vibration system
.10 Exhaust system.
.11 Heating system
.2 System designed to operate as an emergency standby unit. Capable of feeding the loads shown on single line under all operating conditions.
.3 Layout and arrange generating system components so that generating system will be accommodated in ceiling to floor dimension indicated on drawings. Coordinate layout with the structural and mechanical trades.
- 1.4 Shop Drawings .1 Submit shop drawings in accordance with Section 16010 - Shop Drawings.
.2 Include:
.1 Dimensioned drawings of set including engine, alternator, control panel, cooling system and accessories.
.2 Line diagram showing interconnections of alternator, control panel, automatic transfer switch, Voltage regulator, battery, battery charger, governor etc.

- .3 Flow diagrams for: Natural Gas fuel, lubricating oil and cooling air.
- .4 Dimensioned drawing showing complete generating set mounted on steel base, including vibration isolators, exhaust system, drip trays, and total weight.
- .5 Continuous full load output set at 0.8 PF lagging.
- .6 Description of set operation including:
 - .1 Automatic starting and transfer to load and back to normal power, including time in seconds from start of cranking until unit reaches rated voltage and frequency.
 - .2 Manual starting.
 - .3 Automatic shut down and alarm on overcranking, overspeed, high engine temp, low lube oil pressure, short circuit, alternator overvoltage, lube oil high temperature and over temperature on alternator.

1.5 Operation and Maintenance Data

- .1 Provide operation and maintenance data for the generator for incorporation into manual specified in Section 16010.
- .2 Include in Operation and Maintenance Manual instructions for particular unit supplied and not general description of units manufactured by supplier and:
 - .1 Operation and maintenance instructions for engine, alternator, control panel, automatic transfer switch, manual bypass switch, battery charger, battery, fuel system, engine room ventilation system, exhaust system and accessories, to permit effective operation, maintenance and repair.
 - .2 Technical data:
 - .1 Illustrated parts lists with parts catalogue numbers.
 - .2 Schematic diagram of the electrical controls.
 - .3 Flow diagrams for:
 - .1 Fuel system.
 - .2 Lubricating oil.
 - .3 Cooling system.
 - .4 Certified copy of factory test results.

- .5 Maintenance and overhaul instructions and schedules.
- .6 Precise details for adjustment and setting of time delay relays or sensing controls which require on site adjustment.

1.6 Maintenance Materials

- .1 Provide maintenance materials in accordance with Section 16010 - Maintenance Materials, Special Tools and Spare Parts.
- .2 Include:
 - .1 2 fuel filter replacement elements.
 - .2 2 lube oil filter replacement elements.
 - .3 2 air cleaner filter elements.
 - .4 2 sets of fuses for control panel.
 - .5 Special tools for unit servicing.

1.7 Source Quality Control

- .1 Complete system including engine, alternator, control panels, transfer switch and accessories tested to manufacturer's standard factory tests and tests as detailed below.
- .2 Include test results in Operation and Maintenance Manual.
- .3 Tests:
 - .1 With 100% rated load, operate set for 4 h, taking readings at 15 min intervals, and record following:
 - .1 Time of reading.
 - .2 Running time.
 - .3 Ambient temp in °C.
 - .4 Lube oil pressure in kPa.
 - .5 Lube oil temp in °C.
 - .6 Engine coolant temp in °C.
 - .7 Exhaust stack temp in °C.
 - .8 Alternator voltage: phase 1, 2, 3.
 - .9 Alternator current: phase 1, 2, 3.
 - .10 Power in kW.
 - .11 Frequency in Hz.
 - .12 Power Factor.

- .13 Battery charger current in A.
- .14 Battery voltage.
- .15 Alternator cooling air outlet temp.
- .2 After completion of 4 h run, test following shut down devices and alarms:
 - .1 Overcranking.
 - .2 Overspeed.
 - .3 High engine temp.
 - .4 Low lube oil pressure.
 - .5 Short circuit.
 - .6 Alternator overvoltage.
 - .7 Low battery voltage, or no battery charge.
 - .8 Manual remote emergency stop.
 - .9 High alternator temperature.
- .3 Next install continuous strip chart recorders to record frequency and voltage variations during load switching procedures. Each load change delayed until steady state conditions exist.
- .4 Test low oil pressure and high engine temperature shutdown devices operation without subjecting engine to these excesses.

1.8 Warranty

- .1 Provide a written guarantee, signed and issued in the name of the City of Winnipeg, against defects in material and workmanship for a period of five (5) years, or 1500 operating hours, whichever occurs first, from the date of the Final Certificate of Completion.

PART 2 - PRODUCTS

2.1 Natural Gas Engine

- .1 Natural gas engine: to ISO 3046.
 - .1 Engine: standard product of current manufacture, from company regularly engaged in production of such equipment.
 - .2 Turbo charged and aftercooled, synchronous speed 1800 rpm.
 - .3 Capacity: Rated continuous power in kW at rated speed, after adjustment for system losses in auxiliary equipment necessary for engine operation; to be calculated as follows:

Rated continuous output = $\frac{\text{Generator kW}}{\text{Generator Eff @ FL}}$

Under following site conditions:

- .1 Altitude: 300 m.
- .2 Ambient temperature: 40°C.
- .3 Relative humidity: 50%.
- .4 Cooling System:
 - .1 Liquid Cooled: Skid mounted heat exchanger, with ethylene glycol anti-freeze non sludging above 46°C and raw water
 - .2 To maintain manufacturer's recommended engine temperature range at 10% continuous overload in ambient temperature of 40°C.
- .5 Fuel:
 - .1 Dry Processed Natural Gas, 905 BTU/ft² L/H/V.
- .6 Fuel system: solid injection, mechanical fuel transfer pump with hand primer, fuel filters and air cleaner, fuel rack solenoid energized when engine running.
- .7 Governor:
 - .1 Electronic type, electric actuator, speed droop externally adjustable from isochronous to 5%, temperature compensated with steady state speed maintenance capability of plus or minus 0.25%.
- .8 Lubrication system:
 - .1 Pressure lubricated by engine driven pump.
 - .2 Lube oil filter: replaceable, full flow type, removable without disconnecting piping.
 - .3 Lube oil cooler.
 - .4 Engine sump drain valve.
 - .5 Oil level dip-stick.
 - .6 Heater: thermostatically controlled oil pan heater.
- .9 Starting system:
 - .1 Positive shift, gear engaging starter 24 V dc.

- .2 Cranking limiter to provide 3 cranking periods of 10s duration, each separated by 5s rest.
- .3 Lead acid, 24 V storage battery with sufficient capacity to crank engine for 1 min at 0°C without using more than 20% of the rated battery voltage.
- .4 Battery Charger: constant voltage, solid state, two stage from trickle charge at standby to boost charge after use. Regulation: plus or minus 1% output for plus or minus 10% input variation. Automatic boost for 6 h every 30 days. Equipped with dc voltmeter, dc ammeter and on-off switch. Minimum charger capacity: 7 A. Capable of charging batteries to 80% within 4 hours, and full capacity within 12 hours.
- .5 Battery blanket and heater complete with thermostat control.
- .10 Vibration isolated engine instrument panel with:
 - .1 Lube oil pressure gauge.
 - .2 Lube oil temperature gauge.
 - .3 Lube oil level gauge.
 - .4 Coolant temperature gauge.
 - .5 Coolant level gauge.
 - .6 Running time meter: non-tamper type.
- .11 Guards to protect personnel from hot and moving parts. Locate guards so that normal daily maintenance inspections can be undertaken without their removal.
- .12 Drip tray.
- .13 Anti-vibration system

2.2 Alternator

- .1 Alternator: to ANSI/NEMA MG1.
- .2 Rating: 3 phase, 600/347 V, 4 wire, 325 kW, 406 kVA, 60 Hz, at 0.8 PF.
- .3 The neutral shall be on a separate, insulated bushing.
- .4 Output at 40°C ambient:
 - .1 100% full load continuously.
 - .2 110% full load for 1 h.

- .3 150% full load for 1 min.
- .5 Revolving field, brushless, 4-pole, single bearing, Amortisseur windings, EEMAC class H insulation on windings.
- .6 Drip proof.
- .7 Synchronous type
- .8 Rated for **105°C Temperature Rise**.
- .9 Exciter: permanent magnet.
- .10 Platinum resistance temperature transducers embedded in stator winding and connected to alternator control circuitry.
- .11 Voltage Regulator: thyristor controlled rectifiers with phase controlled sensing circuit:
- .12 Alternator: capable of sustaining 300% rated current for period not less than 10 s permitting selective tripping of down line protective devices when short circuit occurs.
- .13 Thermostatically controlled alternator heater. Switch and fuse in heater circuit, mounted in engine-alternator cubicle.

2.3 Control Panel

- .1 Totally enclosed, mounting base isolated from generator.
- .2 Controls:
 - .1 Engine start button.
 - .2 Selector switch: Off-Auto-Manual - Test full load test no load.
 - .3 Engine emergency stop button and provision for remote emergency stop button.
 - .4 Alternator output breaker: bolt-on, moulded case, temperature compensated for 40°C ambient, dual thermal-magnetic trip.
 - .5 Voltage control rheostat: mounted on the inside of the control panel.
 - .6 Operating lights, panel mounted:
 - .1 Green pilot lights for breaker on and red pilot lights for breaker off.
 - .7 Solid state indicator lights (local indication) and **2 normally open (NO), and 2 normally closed relay contacts (NC)**, 120V rated, wired to terminal blocks (for remote annunciation) of each of the following:
 - .1 Engine run
 - .2 Loss of Natural Gas supply.

-
- .3 Low battery voltage.
 - .4 High temperature
 - .5 Low temperature.
 - .8 Solid state controller for automatic shutdown and alarms with 1 normally open, and 1 normally closed 120V rated, contacts wired to terminal blocks for remote annunciation for each of the following:
 - .1 Engine overcrank.
 - .2 Engine overspeed.
 - .3 Engine high temp-ature.
 - .4 Engine low lube oil pressure.
 - .5 Short circuit.
 - .6 AC over voltage.
 - .7 Source 1 Connected and Available
 - .8 Source 2 connected and Available
 - .9 Not in Auto
 - .10 Test / Exercise Active
 - .11 Failed to Disconnect
 - .12 Failed to Synchronize
 - .13 Failed to Transfer/Retransfer
 - .9 Lamp test button.
 - .10 Generator trouble common alarm relay with 2 DPDT dry contacts
 - .11 Generator running relay with 2 DPDT dry contacts.
- 2.4 Automatic Transfer Switch
- .1 Refer to Section 16301-Automatic Load Transfer Equipment
- 2.5 Exhaust System
- .1 Heavy duty critical type horizontally mounted exhaust residential silencer with condensate drain, plug and flanged couplings, exhausting through wall.
 - .2 Heavy duty flexible exhaust pipe with flanged couplings as required.
 - .3 Fittings and accessories as required.
 - .4 Expansion joints: stainless steel, corrugated, of suitable length, to absorb both vertical and horizontal expansion.
- 2.6 Finishes
- .1 Apply finishes in accordance with Section 16010 -

Electrical General Requirements.

- .2 Alternator control cubicle: paint inside, exterior to match engine and alternator.
- .3 Other ducts and racks grey.
- .4 Supply 0.25 L of grey touch-up enamel.

2.7 Equipment Identification

- .1 Provide equipment identification in accordance with Section 16010 - Electrical General Requirements.
- .2 Control panel:
 - .1 Size 4 nameplates for controls such as alternator breakers and program selector switch.
 - .2 Size 3 nameplates for meters, alarms, indicating lights and minor controls.

2.8 Fabrication

- .1 Shop assemble generating unit including:
 - .1 Engine and radiator.
 - .2 Alternator.
 - .3 Control panel.
 - .4 400A 3 pole LSI Breaker
 - .5 Battery and charger.

2.9 Acceptable Manufactures

- .1 Shall be Cummins Gaseous Fuel Generator Set 325 kW, 406 kVA, model GFEA c/w 105°C Alternator, PowerCommand control c/w relay signal module M023
- .2 Approved equal by Caterpillar, ONAN.

PART 3 - EXECUTION

3.1 Installation

- .1 Locate generating unit and install as per the drawings and the manufacturer recommendations.
- .2 Install ventilating air duct system as required to suit new installation.
- .3 Complete wiring and interconnections as indicated.
- .4 Start generating set and test to ensure correct performance of components.

3.2 Field Quality
Control

- .1 Perform tests under the direction of the manufacturer's service representative in accordance with the specifications, and the manufacturer recommendations.
- .2 Notify Contractor Administrator 5 working days in advance of test date.
- .3 Demonstrate:
 - .1 Unit start, transfer to load, retransfer to normal power, unit shut down, on "Automatic" control.
 - .2 Unit start and shut down on "Manual" control
 - .3 Unit start and transfer on "Test" control.
 - .4 Unit start on "Engine start" control.
 - .5 Operation of manual bypass switch.
 - .6 Operation of automatic alarms and shut down devices.
- .4 Run unit on load for minimum period of 2 h to show load carrying ability, stability of voltage and frequency, and satisfactory performance of dampers in ventilating system to provide adequate engine cooling.
- .5 At end of test run, check battery voltage to demonstrate battery charger has returned battery to fully charged state.

END OF SECTION 16238

PART 1 – GENERAL

- 1.1 Related Sections .1 Section 16238 – Emergency Power Generation.
- 1.2 References .1 CAN3-C13-M83, Instrument Transformers.
.2 ANSI/NEMA ICS 2, Industrial Control Devices, Controllers, and Assemblies.
.3 CSA C22.2, No. 14 – M91 Industrial Control Equipment
- 1.3 System Description .1 Automatic load transfer equipment to:
.1 Monitor voltage on all phases of normal power supply.
.2 Initiate cranking of standby generator unit on normal power failure or abnormal voltage on any one phase below preset adjustable limits for adjustable period of time.
.3 Transfer load from normal supply to standby unit when standby unit reaches rated frequency and voltage pre-set adjustable limits.
.4 Transfer load from standby unit to normal power supply when normal power restored, confirmed by sensing of voltage on all phases above adjustable pre-set limit for adjustable time period.
.5 Shut down standby unit after running unloaded to cool down using adjustable time delay relay.
- 1.4 Shop Drawings .1 Submit shop drawings in accordance with Section 016010 – Shop Drawings.
.2 Include:
.1 Make, model and type.
.2 Single line diagram showing controls and relays.
.3 Description of equipment operation including:
.1 Automatic starting and transfer to standby unit and back to normal power.
.2 Test control.
.3 Manual control.
.4 Automatic shutdown.
- 1.5 Closeout Submittals .1 Provide operation and maintenance data for automatic load transfer equipment for incorporation into manual specified in Section 16010.

- .2 Detailed instructions to permit effective operation, maintenance and repair.
- .3 Technical data:
 - .1 Schematic diagram of components, controls and relays.
 - .2 Illustrated parts lists with parts catalogue numbers.
 - .3 Certified copy of factory test results.

PART 2 – PRODUCTS

2.1 Materials

- .1 Instrument transformers: to CAN3-C13.
- .2 Contactors: to ANSI/NEMA ICS 2.

2.2 Contactor Type Transfer Equipment

- .1 Two 3 phase contactors and a separate, fully rated neutral, mounted on common frame, in double throw arrangement, mechanically and electrically interlocked, solenoid operated, with CSA 1 enclosure.
- .2 Rated: 600 V, 400 A, 60 HZ, 3 Pole (3 phase), and ground lugs. Shall be capable of handling 100 percent of rated current continuously in ambient temperatures of -40 to +60 degrees at an altitude of up to 10,000 feet.
- .3 Main contacts: high pressure silver alloy, protected by arc disruption means.
- .4 Switch and relay contacts, coils, spring and control elements accessible for inspection and maintenance from front of panel without removal of switch panel or disconnection of power conductors.
- .5 Auxiliary contact: silver plated, to initiate emergency generator start-up on failure of normal power.
- .6 Fault withstand rating: 14kA symmetrical.

2.3 Controls

- .1 Selector switch – four position “Test”, "Auto", "Manual", "Engine start".
 - .1 Test position – Normal power failure simulated. Engine starts and transfer takes place. Return switch to "Auto" to stop engine.
 - .2 Auto position – Normal operation of transfer switch on failure of normal power; retransfers on return of normal voltage and shuts down engine.
 - .3 Manual position – Transfer switch may be operated

by manual handle but transfer switch will not operate automatically and engine will not start.

- .4 Engine start position – Engine starts but unit will not transfer unless normal power supply fails. Switch must be returned to "Auto" to stop engine.

- .2 Control transformers: dry type with 120 V secondary complete until primary and secondary fusing to isolate control circuits from:

- .1 Normal power supply.

- .2 Emergency power supply.

- .3 Relays: continuous duty, industrial control type, with wiping action contacts rated 10 A minimum:

- .1 Voltage sensing: 3 phase for normal power including loss of phase and 3 phase for emergency, solid state type, adjustable drop out and pick up, close differential, 2 V minimum undervoltage and overvoltage protection.

- .2 Time delay: normal power to standby, adjustable solid state, 0 to 60 s.

- .3 Time delay on engine starting to override momentary power outages or dips, adjustable solid state, 0 to 60 s delay.

- .4 Time delay on retransfer from standby to normal power, adjustable 0 to 60 s.

- .5 Time delay for engine cool-off to permit standby set to run unloaded after retransfer to normal power, adjustable solid state, 0 to 60 s.

- .6 Frequency sensing, to prevent transfer from normal power supply until frequency of standby unit reaches preset adjustable values.

- .4 Solid state electronic in-phase monitor.

2.4 Accessories

- .1 Pilot lights to indicate power availability normal and standby, switch position, green for normal, red for standby, mounted in panel.

-
- .2 Plant exerciser: 168 h timer to start standby unit once each week for selected interval but does not transfer load from normal supply. Timer adjustable 0-168 h in 15 min intervals.
 - .3 Auxiliary relay to provide 1 N.O. and 1 N.C. contacts for remote alarms.
 - .4 Instruments:
 - .1 Digital true rms, indicating type 2% accuracy, flush panel mounting:
 - .1 Voltmeter: ac, scale 0 to 600 V.
 - .2 Ammeter: ac, scale 0 to 400 A.
 - .3 Frequency meter: scale 55 to 65 Hz.
 - .5 Potential transformers - dry type for indoor use:
 - .1 Ratio: 600 to 120.
 - .6 Current transformers - dry type for indoor use:
 - .1 Ratio: 400 to 5.
- 2.5 Equipment Identification
- .1 Provide equipment identification in accordance with Section 16010.
- 2.6 Source Quality Control
- .1 Complete equipment, including transfer mechanism, controls, relays and accessories factory assembled and tested in presence of Consultant.
 - .2 Notify Consultant 7 days in advance of date of factory test.
 - .3 Tests:
 - .1 Operate equipment both mechanically and electrically to ensure proper performance.
 - .2 Check selector switch, in all modes of operation Test, Auto, Manual, Engine Start and record results.
 - .3 Check voltage sensing and time delay relay settings.
 - .4 Check:
 - .1 Automatic starting and transfer of load on failure of normal power.
 - .2 Retransfer of load when normal power supply resumed.

- .3 Automatic shutdown.
- .4 In-phase monitor operation.

2.7 Acceptable Manufactures

- .1 Shall be Cummins OTPC Series
- .2 Approved equals by Caterpillar, ONAN.

PART 3 – EXECUTION

3.1 Installation

- .1 Locate, install and connect transfer equipment.
- .2 Check relays and solid state monitors and adjust as required.
- .3 Provide instructions to the The City on the operations and maintenance of the equipment.

3.2 Field Quality Control

- .1 Energize transfer equipment from normal power supply.
- .2 Set selector switch in "Test" position to ensure proper standby start, running, transfer, retransfer. Return selector switch to "Auto" position to ensure standby shuts down.
- .3 Set selector switch in "Manual" position and check to ensure proper performance.
- .4 Set selector switch in "Engine start" position and check to ensure proper performance. Return switch to "Auto" to stop engine.
- .5 Set selector switch in "Auto" position and open normal power supply disconnect. Standby should start, come up to rated voltage and frequency, and then load should transfer to standby. Allow to operate for 10 min, then close main power supply disconnect. Load should transfer back to normal power supply and standby should shutdown after cool down period.

END OF SECTION 16301

PART 1 - GENERAL

- 1.1 Description .1 The Work described in this Section includes the furnishing of all labour, materials, equipment and services required for the testing of electrical equipment and systems, and assistance in Commissioning.
- 1.2 Codes and Standards .1 All components of the Contractor's work shall comply with all applicable laws, regulations, codes, standards, and with the regulations of the governing inspection authorities at the place of use, including but not limited to the following:
- .1 American Society for Testing and Materials (ASTM);
 - .2 D877 Test for Dielectric Breakdown Voltage of Liquids using Disk Electrodes
 - .3 D923 Method for Sampling Electrical Insulating Liquids
 - .4 Provincial Electrical Protection Branch Regulations
 - .5 Canadian Electrical Codes (CEC) C22.1 and Manitoba Amendments
 - .6 Canadian Standards Association (CSA), Standards
 - .7 National Electrical Manufacturer's Association (NEMA) Standards
 - .8 Electrical and Electronic Manufacturer's Association (EEMAC) Standards
 - .9 Instrument Society of America (ISA) Standards
 - .10 Institute of Electrical and Electronic Engineers (IEEE)
 - .11 International Electrical Testing Association (IETA)
 - .12 Workers Compensation Board (WCB)
- 1.3 Quality Assurance .1 Supplier – Installer Qualifications
- .1 Pre-commissioning and testing of electrical/instrumentation equipment and systems shall be carried out by qualified and experienced personnel who are able to provide evidence that they meet the current recommended qualifications of:
 - .1 The Canadian Interprovincial Standards for Journeyman Electrician in the Electrical Trade or

- .2 The Provincial Standards for Journeyman Electrician or Apprentice Electrician in the Electrical Trade.

1.4 Pre-commissioning

Check Lists and Submittals

- .1 Submit notification to begin Pre-commissioning Checks a minimum of ten (10) working days prior to the start of Pre-commissioning.
- .2 City of Winnipeg personnel and assigned contractor personnel shall be present to witness and complete the Pre-commissioning Checklists.
- .3 Submit two (2) type written copies of Pre-commissioning Checklists to the Construction Supervisor.

1.5 Product Delivery

Storage and Handling

- .1 Store materials in an area designated by the Contract Administrator.

PART 2 - PRODUCTS

2.1 Materials

- .1 Provide all appropriate pre-commissioning/testing equipment and materials, including any necessary calibration equipment and certification that test equipment is calibrated.

PART 3 - EXECUTION

3.1 Installation

- .1 Inspection
 - .1 Do not allow or cause any work performed or installed to be covered up or enclosed by work of this Section prior to the required inspections, tests and approvals.
- .2 General
 - .1 Provide all necessary test equipment.
 - .2 Verify that the nameplate and tag numbers correspond to the specified equipment;
 - .3 Check for damage or deterioration;
 - .4 Verify that the grounding connections are complete;
 - .5 Ensure warning signs, barriers and locks are in place prior to the start of testing.
 - .6 Comply fully with the City's Pre-commissioning/testing and lockout procedures.

- .3 Wires and Cables
 - .1 Inspect all wires and cables to ensure all are numbered with approved markers, and tags in accordance with the drawings.
 - .2 Inspect all connections to ensure connections have been torqued to the values specified.
 - .3 Test each conductor for insulation resistance and circuit continuity.
 - .4 Continuity tests shall be performed with both ends disconnected from the equipment and isolated from ground/earth.
 - .5 Measure continuity of each 600 V / 1000 V power/control conductor and instrumentation conductor with an ohmmeter capable of accurately measuring the expected resistance values.
 - .6 D.C. resistance shall be less than the following values per 300 metres of conductor length.

| AWG | Ohms |
|--------------------|-------------|
| 22 | 17 |
| 20 | 11 |
| 18 | 7.0 |
| 16 | 4.5 |
| 14 | 3.0 |
| 12 | 2.5 |
| 10 | 1.5 |
| 8 | 1.0 |
| 6 | 0.7 |
| 4 | 0.5 |
| 2 | 0.4 |
| 1/0 | 0.3 |
| 1/0, 2/0, 3/0, 4/0 | 0.2 |
| larger than 4/00.1 | |

- .7 To ensure the shield of instrument cables are grounded at one point only conduct the following:
 - .1 Temporarily disconnect the shield from the specified ground point and measure the resistance to ground using a low voltage source ohmmeter;

- .2 If resistance less than 100 mega-ohm determine the location of all connections to ground and isolate/insulate the shield as specified;
- .8 Re-test until all low resistance connections to ground have been eliminated;
- .9 Upon completion of the test reconnect the shield to the specified location.
- .10 Megger test the insulation of each and 600 V / 1000 V cable conductor while the conductors are disconnected from the terminals or terminal blocks. (Note testing while connected to the terminal blocks may damage sensitive control circuits/relays within the equipment).
- .11 Do not Megger test instrumentation cable conductors.
- .12 Megger test voltage for 600 V / 1000 V conductors shall be 1000 V.
- .13 Minimum insulation resistance shall be 100 mega-ohm.
- .4 Grounding
 - .1 Inspect
 - .2 Grounding conductors.
 - .3 Equipment and building grounding accessories and connections.
- .5 Instrumentation
 - .1 Testing and commissioning to be completed as per manufacturer's recommendations and process requirements.
- .6 Motor and Process Control
 - .1 General
 - .1 Verify that the auxiliary transformers, fuses, overloads and current transformers have been properly installed and connected.
 - .2 Motors & Motor Controllers
 - .1 Perform operational testing per manufacturer's recommendations of motors, motor control, starters, instruments, interlocks, speed controls, I/O interlocks, auxiliary contacts, relays, and motor rotation.

- .2 Contractor to program/commission soft starters.
- .3 Measure each phase current for all motors, both loaded and unloaded. Record and advise Inco Construction Supervisor where current unbalance exceeds manufacturer's recommendations.
- .7 Low Voltage Equipment Testing
 - .1 Measure the insulation resistance of 600 Volt equipment using a 1000 volt megger;
 - .2 Resistance phase to phase (A to B, B to C, and C to A);
 - .3 Resistance of each phase to ground;
 - .4 Measure the insulation resistance of the following using a 500 volt megger;
 - .5 Resistance of 120 V windings of control transformers to ground;
 - .6 Resistance of 120 V winding to 600 V winding;
 - .7 Insulation resistance shall be minimum 100 mega-ohm;
 - .8 Insulation resistance values recorded for transformers shall be adjusted to 20⁰C.
- .8 Emergency Power Generation Equipment
 - .1 To be tested and commissioned in accordance with Section 16238 and as per manufacturer's recommendation.
 - .2 Testing and commissioning to be completed under the direction of the manufacturer's representative. Contractor shall pay for all costs including all services provided by manufacturer's representative
- .9 Automatic Load Transfer Equipment
 - .1 To be tested and commissioned in accordance with Section 16301 and as per manufacturer's recommendation.
 - .2 Testing and commissioning to be completed under the direction of the manufacturer's representative. Contractor shall pay for all costs including all services provided by manufacturer's representative

- .10 Natural Gas Detection System
 - .1 To be tested and commissioned in accordance with the manufacturer's recommendations.
 - .2 Testing and commissioning to be completed under the direction of the manufacturer's representative. Contractor shall pay for all costs including all services provided by manufacturer's representative

3.2 Preparation

- .1 Assume full responsibility for all construction means and coordinate with The City and other Trades.

END OF SECTION 16950