

1. GENERAL

1.1. General

- 1.1.1. These General Electrical Provisions shall apply to and govern all sections of Division 16 of the Specification.
- 1.1.2. Division 16 of the Specification is an integral part of the Contract Documents and shall be read accordingly.
- 1.1.3. Coordinate with other Divisions of the specification.
- 1.1.4. All new electrical wiring, equipment, and new local control panels are to be supplied to meet the electrical and environmental classifications of area in which they are to be installed. For areas designated as Class I Division 1 or 2 include appropriate conduit seals, junction boxes, materials, and all other appurtenances as necessary and installation techniques as required by applicable codes and regulations.
- 1.1.5. All new local control panels in areas not classified as Class I, Division 1 or 2 to be NEMA 3R enclosures, unless indicated otherwise.
- 1.1.6. All wiring to be in rigid steel conduits or HL Teck Cable unless indicated otherwise in the contract documents, or unless field conditions dictate otherwise and approved by the Consultant.
- 1.1.7. The Specification is divided into divisions of work and a division may consist of the work of more than one subcontractor. The responsibility as to which subcontractor provides labour, materials, equipment and services required to complete the work rests solely with the Contractor.

1.2. Intent of Section

- 1.2.1. This section covers the following:
 - 1.2.1.1. Submittals for Electrical Work.
 - 1.2.1.2. Identification of equipment
 - 1.2.1.3. General electrical methods.
 - 1.2.1.4. Start-up, testing and commissioning.

1.3. Codes and Standards

- 1.3.1. Apply for, obtain and pay for all permits, licenses, inspections, examinations and fees required.
 - 1.3.2. Arrange for inspection and any testing of all work by the Authorities having jurisdiction over the work. On completion of the work, present to the Owner the final unconditional certificate of approval of the Inspection Authorities.
 - 1.3.3. Comply with the requirements of the latest edition of the applicable CSA Standards, and Ontario Electrical Safety Code, the requirements of the
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Authorities, Federal, Provincial and Municipal Codes, the applicable Standards of the underwriters' Association and all other authorities having jurisdiction. These codes and regulations constitute an integral part of these Specifications. In case of conflict, the codes take precedence over the Contract Drawings. In no instance reduce the standard established by the drawings and specifications by applying any of the codes referred to herein.

- 1.3.4. Before starting any work, submit the required number of copies of drawings and specifications to the Authorities for their approval and comments. Comply with any changes requested as part of the Contract, but notify the Consultant immediately of such changes for proper processing of these requirements. Prepare and furnish any additional drawings, details for information as may be required.

Workmanship and Materials

- 1.3.5. Contractor shall employ only certified tradesmen fully qualified and experienced in each area of work required.
- 1.3.6. Work shall be executed in a professional manner and shall present a completed work appearance as generally accepted in the trade.
- 1.3.7. All materials shall be new and of the highest quality available and must bear CSA approval. Where there is no alternative to supplying equipment or material which is not CSA certified, the Contractor shall be responsible for obtaining special approval from Inspection Authorities at his own cost.
- 1.3.8. Install equipment as per the installation details as indicated in the contract documents. Where no specific installation detail is indicated, use appropriate installation detail per the field requirements. Installation details are included as an appendix to the Specifications.

Contract Drawings

- 1.3.9. Follow the Contract Drawings to become familiar with all conditions affecting the work, and verify spaces in which the work will be installed.
- 1.3.10. The drawings for electrical work are performance drawings, diagrammatic, intended to convey the scope of work and indicate general arrangement and approximate location of apparatus, fixtures and approximate sizes and location of equipment and outlets. The drawings do not show architectural and structural details.
- 1.3.11. Do not scale the drawings to determine dimensions, but obtain information for accurate dimensions by referring to architectural and structural drawings, or by site measurements.
- 1.3.12. Become familiar with the condition of the existing power and control equipment. Allow for errors and omissions in the power and control schematics of the existing equipment and ensure that the tender price includes the provisions to make the necessary field reviews, field verifications, field changes, and drawing changes to suit the intent of the controls required.
- 1.3.13. Work which is indicated, but not completely detailed shall be installed by common practice or as directed by the Consultant.
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- 1.3.14. Make, at no additional cost, any changes or additions to materials, and/or equipment necessary to accommodate structural conditions (runs around beams, columns, etc.).
- 1.3.15. Alter, at no additional cost, the location of materials and/ or equipment as directed, provided that the changes are made before installation and do not necessitate additional material.
- 1.3.16. Ceiling mounted components (lighting fixtures, detectors) shall be installed in accordance with reflected ceiling drawings, reviewed by the Consultant and Manufacturer's recommendation.
- 1.3.17. Leave space clear and install work to accommodate future materials and/or equipment as indicated and to accommodate equipment and/or material supplied by other trades. Verify spaces in which work is to be installed. Install conduit and cable runs to maintain headroom and clearances to conserve space.
- 1.3.18. Confirm on the site the exact location of outlets and fixtures. Confirm location of outlets for equipment supplied by other trades.
- 1.3.19. The drawings, specifications, and standards are complimentary to one another, meaning that, that which is called for on one is meant to be called for on all. Where conflict exists between the Sections, Standards and/or Drawings, it shall be referred to the Consultant for clarification and rectification before any material is purchased or electrical work commences. Code requirements shall be considered a minimum standard. When materials shown on drawings as indicated in the specifications exceed code requirements, the plans and specifications shall govern. If, having examined all documents pertaining to Division 16, concerning the nature and extent of the work being performed under other sections, clarification of the item and/or items in question will come from the Consultant.

1.4. Submittals

- 1.4.1. Conform to the requirements of the contract documents, except as varied by this Section.
 - 1.4.2. Assume responsibility for accuracy of equipment dimensions related to available space and accessibility for maintenance and service, and compliance with codes and inspection authorities. Ensure that working drawings indicate the shipping and working weight of all equipment.
 - 1.4.3. Obtain manufacturer's installation directions to aid in properly executing the work. Submit two copies of such directions to the Consultant prior to installation, for use in inspecting the work.
 - 1.4.4. Bind one complete set of reviewed working drawings in each operating and maintenance instruction manual.
 - 1.4.5. In addition to the requirements of the contract documents, provide working drawings with the following additional information:
 - 1.4.5.1. Manufacturer's and Supplier's name.
 - 1.4.5.2. Catalogue model number.
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- 1.4.5.3. Number identifying item on the drawings and/or in the specifications such as equipment, item number, panel identification letters, etc.
 - 1.4.5.4. Indicate details of construction, dimensions, capacities, weights and electrical performance characteristics of equipment or material.
 - 1.4.5.5. Where applicable, include wiring, single line and schematic diagrams.
 - 1.4.5.6. Include wiring diagrams or diagrams showing interconnections with work of other sections.
 - 1.4.6. Contractor is responsible for providing shop drawings showing the integration between supplied control panels and control panels supplied with equipment. These drawings are to be a single drawing for each specific device, showing interconnection between the device and all associated panels and terminal blocks. The Consultant reserves the right to request more detailed drawings if those provided are deemed insufficient.
 - 1.4.7. Submit samples of material and equipment where specified or as may reasonably requested by the Consultant for review before ordering same in accordance with Division 1. The Consultant may retain the samples until the completion of the contract.
 - 1.4.8. Complete all work in accordance with reviewed shop drawings.
 - 1.4.9. Where conduits, cable trays and lay-in ducts are not detailed, submit conduit, cable tray and wiring layout drawings. Show conduit/tray and cable sizes including number of cables/conductors in each conduit/tray. Drawings shall be on the same size sheets as the contract drawings.
 - 1.4.10. Update single line electrical diagrams to include any modifications to the electrical distribution system.
- 1.5. Control Schematic Diagrams**
- 1.5.1. See Contract Drawings.
- 1.6. Record Drawings**
- 1.6.1. Comply with requirements for record drawings stated in the contract documents.
 - 1.6.2. Show on the record drawings as-built, all outlets and equipment such as runs of conduit, locations of pull boxes, outlets, motors, panels, etc., as well as all services entering the building and on the property. Dimension underground services and concealed main and sub-feeder conduits at key points of every run in relation to structure and building. Record all elevations for underground services in relation to the ground floor level of the building.
 - 1.6.3. Indicate exact location of all services left for future work.
- 1.7. Operations and Maintenance Manuals**
- 1.7.1. Comply with requirements for operating and maintenance manuals stated in the contract documents.
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1.7.2. In addition to the requirements of the contract documents, include in the Operations and Maintenance Manuals:

1.7.2.1. 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.

1.7.2.2. Technical data, product data, supplemented by bulletins, component illustrations, exploded views, technical descriptions of items and parts lists. Advertising or sales literature not acceptable.

1.7.2.3. Wiring and schematic diagrams and performance curves.

1.7.2.4. Names and addresses of local suppliers for items included in Maintenance Manuals.

1.7.2.5. Copy of test data.

1.7.2.6. Recommended spare parts list and unit cost.

1.8. Operation Instructions

1.8.1. Comply with requirements of the contract documents.

1.8.2. Upon completion of testing, provide on-site operating instructions by certified and experienced personnel to the operating/maintenance personnel at their convenience.

1.8.3. Provide these services as necessary to put equipment in operation. Ensure that plant staff, operating/ maintenance are conversant with its care and operation.

1.9. Delivery, Storage and Handling

1.9.1. See Division 1.

2. PRODUCTS

2.1. Warning Signs

2.1.1. Provide warning signs, as specified or to meet requirements of Inspection Authorities, Consultant, and the Owner.

2.2. Wiring Identification

2.2.1. Identify wiring with permanent indelible identifying markings, either numbered or coloured plastic taped, on both ends of phase conductors of feeders and branch circuit wiring.

2.2.2. Maintain phase sequence and colour coding throughout.

2.2.3. Colour code: to applicable CSA standard:

2.2.3.1. Phase A - Red: Phase B - Black: Phase C - Blue

- 2.2.3.2. Neutral - White Only.
 - 2.2.4. Use colour codes wires in communication cables, matched throughout system.
 - 2.2.5. All instrumentation and control wiring is to be identified with markers as specified. The identification is to consist of the coding as detailed on the drawings and as specified herein.
 - 2.2.6. Tag field wires with the field device tag and terminal information:
 - 2.2.6.1. For devices connected to control panels or RPUs, show field source and destination information.
 - 2.2.6.2. For devices connected to other panels (e.g. MCC) show field source information.
 - 2.2.6.3. Label wires at both ends with the same information.
 - 2.2.6.4. Wire number should not change unless there is a function change in the wire run i.e. a fuse, a relay, etc. Wires passing through a junction box without a change in function would retain the same wire number.
 - 2.2.6.5. Generally, keep the wire tag to 18 characters or less. For longer tags, use smaller font.
 - 2.2.7. Field source information consists of the following:
 - 2.2.7.1. In most cases, the device type (up to 4 characters) and loop number (up to five characters) make up the device tag information needed on the labels.
 - 2.2.7.2. Add a number or character (+,-) to each wire from the field device to make the field information unique for each wire.
 - 2.2.7.3. In a few cases, the process code (three characters) may be needed to make the wire tag unique.
 - 2.2.7.4. It is not necessary to include spaces, hyphens or leading zeroes in the field source information.
 - 2.2.8. Cable numbers
 - 2.2.8.1. Field cables should be tagged with the field device tag information at both ends.
 - 2.2.8.2. Where cables carry wires from multiple field devices, the cable tag should use the device tag of the junction box.
 - 2.2.8.3. For cables tags, use P or C or I added to the device tag for Power, Control and Instrument respectively as some devices such as valves have all three cables.
 - 2.2.8.4. Cable numbering should show the Junction Box relevant numbers in that a cable runs to a JB, but the wiring itself would not have such designation.
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2.2.8.5. For example, in the case of a Cable from a Junction Box to an RPU, assign a unique "loop/device number" to the Junction Box and treat it as a Device.

2.2.8.6. A Cable schedule will be provided showing Cable I.D., Cable Type, Origin, and Destination.

2.2.9. Wire Markers

2.2.9.1. Wire markers available from Brady amongst others allow more than one line of characters if required but one line should be used if possible.

2.2.9.2. Wire markers should be kept to a minimum for ease of installation and readability. A single line of text should be used, minimizing the characters as much as possible.

2.3. Equipment Identification

2.3.1. Identify all equipment listed below with lamacoid plastic plates, white background with black engraved letters 6 mm high, unless otherwise noted.

2.3.2. Lighting panel: Plates shall be mounted on inside of door, typical identification - "Lighting Panel `A` 120/240 V, 1 phase, 3 wire".

2.3.3. Disconnect switches and starters: Plates shall be mounted externally on switch box cover. Typical identification - "Pump No. 600 V, 3 phase".

2.3.4. Power Panel Board: Plates shall be mounted on face - Typical identification - "Pump No."

2.3.5. Plates shall be installed after all painting has been completed and shall be secured with self-tapping screws except on the inside of panel door where gluing will be accepted.

2.3.6. Have the manufacturers' nameplates affixed to each equipment showing the size, name of equipment, serial number and all information usually provided, including voltage, cycle, phase, horsepower, etc. and the name of the manufacturer and his address. Ensure that all stamped, etched or engraved lettering on plates is perfectly legible. Do not paint over nameplates.

2.3.7. Identify all equipment with the corresponding remote controls.

2.3.8. Panels and other apparatus which have exposed faces in finished areas shall not have visible trademarks or other identifying symbols. Nameplates shall be mounted behind doors.

3. EXECUTION

3.1. Painting

3.1.1. Touch up all electrical equipment marred by shipment or during the period of construction, using the same paint, colour and finishes originally used.

3.2. Cutting, Fitting, and Patching

- 3.2.1. Locate and provide holes and sleeves required for electrical work relocate improperly located holes and sleeves at no cost.
- 3.2.2. Conform to the requirements of Division 1 in respect to cutting, patching, and fitting electrical equipment.

3.3. Concrete

- 3.3.1. Coordinate all related electrical work.

3.4. Mounting Heights

- 3.4.1. Mounting height of equipment is from above finished floor (AFF) to centreline of equipment unless specified or indicated otherwise.
- 3.4.2. If mounting height of equipment is not indicated, verify before proceeding with installation.
- 3.4.3. Install electrical equipment at the following heights unless indicated otherwise:
 - 3.4.3.1. Local switches: 1,219 mm
 - 3.4.3.2. Wall receptacles:
 - 3.4.3.2.1. General: 300 mm dwelling units and offices, otherwise 1,219 mm Above Finished Floor (AFF).
 - 3.4.3.2.2. Above top of counters of splash back: 177 mm
 - 3.4.3.2.3. In mechanical rooms: 1,219 mm
 - 3.4.3.3. Panelboards: 2,000 mm, or as required by Code
 - 3.4.3.4. Telephone outlets: 300 mm, in offices and dwelling units, otherwise 1,219 mm AFF
 - 3.4.3.5. Thermostats: 1,400 mm
 - 3.4.3.6. Disconnects: 1,400 mm

Protection

- 3.4.4. Protect the work of others from damage resulting from the work of this project.
 - 3.4.5. Protect the work of this project from that of others, make good any damage, remove all debris and rubbish and leave the project site in a clean and tidy condition to the approval of the Consultant.
 - 3.4.6. Protect exposed line equipment during construction for personnel safety. Shield and mark live parts "Live 120 Volts", or with appropriate voltage.
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3.5. Manufacturer's and CSA Labels

- 3.5.1. Manufacturer's nameplates and CSA labels to be visible and legible after equipment is installed.

3.6. Cleaning

- 3.6.1. Clean during construction and make final cleaning in accordance with Division 1.
- 3.6.2. Before energizing any systems, inspect and clean all the inside of power panel boards and cabinets to ensure that they are completely free from dust and debris.
- 3.6.3. Clean all polished, painted and plated work brightly. Clean all lighting fixtures and replace all burned out lamps.
- 3.6.4. Remove all debris, surplus material and all tools.
- 3.6.5. At time of final cleaning, clean lighting reflectors, lenses, and other lighting surfaces that have been exposed to construction dust and dirt.

3.7. Coordination of Protective Devices

- 3.7.1. Ensure circuit protective devices such as over-current trips, relays and fuses, are installed to correct values and settings.

3.8. Testing

- 3.8.1. Comply with requirements of the contract documents requirements for start-up, testing and commissioning.
- 3.8.2. All equipment and electrical systems which are provided under this Division shall be performance tested for electrical and mechanical defects and all defects and adjustments made, prior to requesting inspection by the Consultant.
- 3.8.3. Submit original copies of letters from the manufacturers of auxiliary systems indicating that their technical representatives have inspected and tested the respective systems and are satisfied with the methods of installation, wiring and operation.
- 3.8.4. Perform tests using certified personnel only. Provide necessary instruments and equipment for testing.
- 3.8.5. Insulation and continuity tests shall be performed for all wiring and equipment installed under this Division. Insulation tests shall be performed with a "Megger" insulation tester and recorded in log book for reference. Lighting and power circuit feeders shall be meggered and if resistance to ground is less than 0.5 mega ohms on any lighting or power circuit, such circuit shall be considered defective and shall be replaced.
- 3.8.6. Conduits or ducts which are required to be installed but left empty shall be tested for clear bore using a ball mandrel of approximately 85% of the conduit or duct inside diameter. Any conduit or duct which rejects the ball mandrel shall be cleared at no additional cost to the Owner. These tests shall be witnessed by the Consultant. Three days notice shall be given prior to testing.
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- 3.8.7. Single phase loads on three phase system shall be connected so that there is the least possible imbalance of the supply.
- 3.8.8. All testing shall be scheduled and coordinated through the Consultant. No testing of any kind shall be done without this clearance.

3.9. Trial Usage

- 3.9.1. The City has the privilege of the trial usage of electrical systems or parts thereof for the purpose of testing and learning the operational procedures.
- 3.9.2. Carry out the trial usage over a length of time as deemed reasonable by the Consultant, at no extra cost.
- 3.9.3. Carry out the operations only with the express knowledge and under supervision of the Subcontractor who shall not waive any responsibility because of trial usage.
- 3.9.4. Trial usage shall not be construed as acceptance by the Owner.

3.10. Final Inspection

- 3.10.1. Make request, in writing, to the Consultant to arrange for a final inspection of all electrical systems with a schedule of inspections.
- 3.10.2. Do not issue this written request until:
 - 3.10.2.1. All deficiencies noted during the job inspection have been completed.
 - 3.10.2.2. All systems have been balanced and tested and are ready for operation.
 - 3.10.2.3. Operating and maintenance instructions have been submitted and approved.
 - 3.10.2.4. Identification of equipment and raceways is complete.
 - 3.10.2.5. Certificates have been submitted.
 - 3.10.2.6. Spare parts and replacement parts specified have been provided and receipt of same acknowledged, in accordance with Section 01700 – Project Closeout.
 - 3.10.2.7. Record drawings are completed and approved.
 - 3.10.2.8. Owner's operating personnel have been instructed.

3.11. Demonstration of Complete Electrical Systems

- 3.11.1. Instruct the Owner's representatives in all aspects of the operation of systems and equipment.
 - 3.11.2. Arrange for, and pay for services of service engineers and other manufacturers' representatives required for instruction on specialized portions of the installation.
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3.11.3. Submit to the Consultant at the time of final inspection, a complete list of systems stating for each system:

3.11.3.1. Date instructions were given to the Owner's staff

3.11.3.2. Duration of instruction

3.11.3.3. Name of persons instructed

3.11.3.4. Other parties present (Manufacturer's representative, consultants, etc.)

3.11.3.5. Signature of Owner's staff stating that they properly understand the system installation, operation and maintenance requirements.

3.12. System Acceptance

3.12.1. Submit original copies of letters from the manufacturers of all systems indicating that their technical representatives have inspected and tested the respective systems and are satisfied with the methods of installation, connections and operation. Where existing systems are extended, such letters shall cover both new and existing equipment and connections.

3.12.2. These letters shall state the names of persons present at testing, and methods used, and a list of functions performed with location and room numbers where applicable.

END OF SECTION

1. GENERAL

1.1 General

1.1.1 Comply with the requirements of the contract documents.

1.2 Grounding

1.2.1 This section covers the supply and installation of a grounding system as applied to installation of new panels and insulation resistance tests of each circuit and extension to the existing system.

1.2.2 The ground resistance of the system shall not exceed 4 ohms for low potential systems and 1 ohm for high potential installations.

1.2.3 Existing system grounds to be checked for integrity and compliance with the latest Ontario Electrical Safety Code and Canadian Electrical Code.

1.2.4 Contractor is responsible for upgrading the existing grounding system in order to ensure code compliance.

1.3 Governing Conditions

1.3.1 Latest edition of Ontario Electrical Safety Code and Bulletins.

2. PRODUCTS

2.1 Materials

2.1.1 Grounding equipment to: CSA C22.2 No. 411950 (R 1967).

2.1.2 Copper grounding conductors to: ANSI G7.1-1964.

2.2 Equipment

2.2.1 Clamps for grounding of conductor, size as required to building ground or electrical grounding grid.

2.2.2 System and circuit, equipment, grounding conductors, bare stranded copper soft annealed, size as indicated.

2.2.3 Non-corroding accessories, necessary for grounding system, type, size, material as required, or as indicated, including but not necessarily limited to:

- .1 Grounding and bonding brushings
 - .2 Protective type clamps
 - .3 Bolted type conductor connectors
 - .4 Bonding jumpers, straps
 - .5 Pressure wire connectors
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3. EXECUTION

3.1 Execution

- 3.1.1 Test the grounding system within the scope of work for continuity of connections and for resistance to the flow of current through ground connections.
- 3.1.2 All equipment must be provided with a proper grounding and bondings as per Ontario Electrical Safety Code.

END OF SECTION

1. GENERAL

1.1 General

- 1.1.1 Comply with the requirements of the contract documents.
- 1.1.2 Comply with the requirements of the Ontario Electrical Safety Code.

1.2 Governing Conditions

- 1.2.1 The drawings are not intended to show in detail, the location and size of every conduit/conductor/wire.
- 1.2.2 Where cable is not shown or indicated as “Xc”, this refers to the number of conductor cables of the size as required plus a suitable ground wire sized appropriately as per code requirements.
- 1.2.3 Colour code single conductors forming part of a multiple conductor cable for phase identification.

Line	Lighting & Power
Line 1	Red
Line 2	Black
Line 3	Blue
Neutral	White
Ground Wire	Green

- 1.2.4 Phase relationships and terminal arrangements:

Left	Middle	Right
Line 1 Phase: Red	Line 2 Phase: Black	Line 3 Phase: Blue

1.3 Requirements

- 1.3.1 Provide colour coding of insulated conductors conforming to the following:
 - 1-conductor power - Black (phase conductors),
- White (neutral)
 - 1-conductor control - Red
 - 2-conductor cable - Black, white
 - 3-conductor cable - Red, Black, White (neutral)
 - 4-conductor cable - Red, Black, Blue, White
 - Multi-conductor cables - Manufacturer's standard

2. PRODUCTS

2.1 Wires

- 2.1.1 Conductors: stranded copper for all wire sizes.

- 2.1.2 Copper conductors: sized as indicated or required, with 600 volt RW 90 insulation for conductors up to size #10 and 1000 volt RW 90 insulation for conductors size #8 and larger to CSA C22.2 No. 38 - latest edition. For direct buried installations or where indicated on drawings use TECK cable.
- 2.1.3 Minimum conductor size for power and lighting wiring: #12 AWG. Use GTF fixture wire, 600 V, 125 °C, flexible copper conductor for all connections between lighting fixtures and outlet boxes
- 2.1.4 Minimum conductor size for control monitoring, and indication circuit wiring: #14 AWG, coloured per unit function.
- 2.1.5 Flexible cable for pendant equipment - Type SEW 600 volt, 4 conductor.
- 2.1.6 Ground wires - bare copper with green RW 90 insulation when run in ducts, banks, tray or conduit.

2.2 Instrumentation Signal Cables

- 2.2.1 In conduit: fully shielded twisted pair, insulated stranded copper, aluminum-Mylar shield, bare copper drain wire with extended PVC jacket, conductor size #16 AWG.

2.3 Wiring Identification

- 2.3.1 Identify all wiring in accordance with Section 16010.

2.4 Wiring Signal Level Separation

- 2.4.1 Provide cables installed exposed, or underground with an aluminum or steel interlocking armour with an overall PVC jacket, i.e. TECK cables.
- 2.4.2 General purpose instrumentation cable to be approved equal to Belden #9318.
- 2.4.3 RS232 and RS485 cables to be 4 pair, 18 AWG stranded copper, each pair separately twisted. Provide overall 100% shield and tinned stranded drain wire. Cable to be approved equal to Belden #9305. Termination fittings to be of the type, configuration and gender required to connect cable directly to equipment without additional adapters or fittings.

2.5 Wiring Accessories

- 2.5.1 Provide plastic slip-on wire markers, black letters on white background, of one of the following manufacturers:

Electrovert Z-Type
Thomas & Betts Shur-Code

- 2.5.2 Provide cable markers for cables or conductors greater than 13 mm diameter, strap-on type, rigid PVC covered aluminum straps, as manufactured by:

Electrovert Cat. no. 510

- 2.5.3 Provide identified terminal blocks, minimum 600 V, 25 A rated, modular, 35 mm DIN rail mounted, individually removable, sized to accommodate conductor size and circuit current used, as manufactured by:

Entrelec
Phoenix
Schlegel
Weidmuller

- 2.5.4 Where screw-type terminals are provided on equipment, terminate field wiring with insulated fork tongue terminals, as manufactured by:

Thomas & Betts Sta-Kon
3M Scotchlok

3. EXECUTION

3.1 Installation of Wiring

- 3.1.1 Install all wiring as follows:
- .1 In conduit system.
 - .2 Use CSA approved lubricants of type compatible with cable jacket to reduce pulling tension.
- 3.1.2 All cables for systems other than power shall be of the type specified in the respective sections.
- 3.1.3 Run all feeders continuous length between power supply point and the load. No splices will be allowed in feeder cable.
- 3.1.4 Wire shall be placed in conduit without excessive strain or kink and fishpaper will be provided where required to prevent cables from resting against metal enclosures. Prior to using lubricants, check with the cable manufacturer as to what type of lubricant is approved for the specific cables in use.
- 3.1.5 Identify the circuits in the lighting panel and power panels with cable markers as indicated on the drawings. If the wiring is installed with different circuitry, review the "as-built drawings" in plan to determine the new circuit number which has been given to the outlet or receptacle. The legends in all panels shall be made up to agree with the wiring as installed.
- 3.1.6 All cables shall be identified in pullboxes, etc., with Electrovert Type Z markers , Electrovert strap-on markers or T & B SM markers.
- 3.1.7 All wiring for signal systems shall be identified as to circuit numbers with approved markers on the cables at all panels and terminal strips.
- 3.1.8 When the routing of the cables is not indicated on a drawing or described in the installation specification; the contractor should submit details of the proposed routing for approval prior to commencing the installation.
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3.2 Installation

- 3.2.1 Install instrumentation signal cables as indicated. Use shielded instrumentation cables for all 4-20 mA DC or 1-5 VDC signals that are connected to the instrumentation and SCADA systems. No more than two wires connected to one terminal point.
- 3.2.2 Each instrument loop should have its own power supply disconnection switch to enable servicing without affecting other loops.
- 3.2.3 Ground the cable shields at the receiving end (RPU) only. Where cables are joined at terminal strips in terminal boxes or panels between the transmitter and receiver for series connections, join the shields but do not ground.
- 3.2.4 Only one ground must be maintained, multiple grounds result in ground loop (grounds at different potential).

3.3 Wiring Signal Level Separation

- 3.3.1 In order to control or eliminate electrical noise in plant wiring systems, group wires of compatible signal or power levels together but run separately or electromagnetically isolated from wires of incompatible signal or power level.
- 3.3.2 Provide neoprene or chrome vinyl jacket over complete assembly.
- 3.3.3 Identify each grouping (pair, triplet, quad) by consecutive number coding permanently marked at 25 mm intervals.

END OF SECTION

1. GENERAL

1.1 General

1.1.1 Comply with the requirements of contract documents.

1.2 Codes

1.2.1 All conduits to meet CSA Specification C22.2 No. 45.

1.2.2 Size conduits according to Table 6 or 9 of the Ontario Electrical Safety Code, unless otherwise indicated.

1.3 Conduit and Fittings

1.3.1 Supply and install all conduits and fittings required for the installation.

2. PRODUCTS

2.1 Conduits

2.1.1 Rigid aluminum or rigid steel conduit sized as indicated or required, minimum size 21 mm, approved for hazardous locations where required.

2.1.2 EMT may be used in non-hazardous locations.

2.2 Conduit Fittings

2.2.1 Fittings, as required, for use with conduit specified, with coating same as conduit.

2.2.2 Galvanized rigid steel for rigid galvanized steel conduit.

2.2.3 All locknuts and bushings shall be of T & B or Efcor in manufacture. All bushings shall be of the insulated type or a locknut and an insulating bushing may be used.

2.2.4 Approved for hazardous locations where required.

2.3 Expansion Fittings for Rigid Conduit

2.3.1 Expansion sleeves with bonding where conduit crosses a structural expansion joint, Crouse Hinds fitting complete with grounding strap and clamps.

2.3.2 For hazardous areas provide rigid galvanized steel conduit fittings, compound etc., to conform to the code requirements for the specific type of hazard present, Class 1, Division 1, Group D.

3. EXECUTION

3.1 Location of Conduits

3.1.1 Install conduit into the walls, ceilings or floors as required on the Contract Drawings. The actual route of the conduits to be selected to avoid beams,

columns and other obstructions, provided permission has been granted by the City Project Manager.

- 3.1.2 Conduit shall not interfere with other trades and shall be mounted over other piping where possible in parallel rows, parallel or perpendicular to walls and ceilings. Bends and offsets shall be uniform and symmetrical. The use of conduit bends shall be kept to a minimum.
- 3.1.3 Conduit and cables shall be installed to avoid proximity of water and heating pipes. In no case shall they run within 75 mm of such pipe except where crossings are unavoidable in which case they shall be kept at least 25 mm from the covering of pipe crossing.
- 3.1.4 Ensure that no conduit or pullboxes are closer than 200 mm to heating equipment.

3.2 Installation

- 3.2.1 Where conduit painting is noted on Contract Drawings, coordinate installation of conduit with painting contractor.
 - 3.2.2 Conceal conduits, ducts, and wiring in floor, wall, and ceiling construction of finished areas except where indicated otherwise.
 - 3.2.3 Install conduits and fittings to be embedded or plastered over, neatly and close to building structure so furring can be kept to a minimum
 - 3.2.4 Install expansion sleeves with bonding wherever conduits cross a structural expansion joint. Install conduit and sleeves prior to pouring of concrete. Sleeves through concrete: Schedule 40 steel pipe, sized for free passage of conduit and protruding 50 mm.
 - 3.2.5 Cut all threads on conduit neatly with the ends square and the inner diameter reamed smooth to remove burrs.
 - 3.2.6 Provide junction or pull boxes where the number of right angle bends in one run exceeds three.
 - 3.2.7 Cap all open ends of conduit with proper threaded caps immediately after installation to prevent entrance of foreign materials. Do not use wooden plugs.
 - 3.2.8 Form a continuous metallic path with all conduit and fittings in accordance with the latest requirements of the Ontario Electrical Safety Code, to the satisfaction of the local inspector.
 - 3.2.9 For conduit connections to all equipment whose position is subject to adjustment or vibration, use flexible galvanized steel conduit with a PVC jacket equal to "Sealtite" for a length not exceeding 500 mm.
 - 3.2.10 Where cables or conduits pass through floors and fire rated walls, pack space between wiring and sleeve with approved material and seal with caulking conforming to CGSB 19-GP-9 mA.
 - 3.2.11 Use Liquid-Tight flexible steel conduit for connection to motors, except as indicated.
-

- 3.2.12 All conduits which are laid in reinforced concrete shall be installed after the reinforcing is in place. Conduits placed in the centre of the structural slab shall not be more than 25 mm I.P.S., except for those conduits shown.
- 3.2.13 Conduits passing through a membrane under a floor slab shall be sealed against moisture to the City's approval.
- 3.2.14 Conduit shall be installed with minimum number of joints.
- 3.2.15 All conduits shall be supported at intervals as required by the Code
- 3.2.16 Install nylon fish cord in empty conduits. Identify the empty conduits.
- 3.2.17 Minimum size of conduits shall be 21mm.
- 3.2.18 All conduits installed in hazardous areas are to be equipped with EYS seals as required by the Ontario Electrical Safety Code.

3.3 Cable Installation

- 3.3.1 Swab clean and dry the inside of all embedded conduits prior to cable pulling.
- 3.3.2 Do not exceed the number of wires in any conduit per the requirements of the current edition of the Ontario Electrical Safety Code.
- 3.3.3 Do not pull any group of wires sufficient to damage or distort them and use only, an approved silicone base (greaseless) lubricant to facilitate pulling.

END OF SECTION

1. GENERAL

1.1 General

- 1.1.1 Comply with the requirements of the contract documents.
- 1.1.2 Gang boxes where wiring devices are grouped, except for standard sectional type boxes which shall not be ganged
- 1.1.3 Use combination boxes with barriers where outlets for more than one system are grouped.

1.2 Codes

- 1.2.1 Size boxes in accordance with CSA C22.1-1978, Section 12-3042.

2. PRODUCTS

2.1 Conduit Boxes

- 2.1.1 Cast metal type FS or FD boxes with factory hubs and mounting feet for surface wiring of switches and receptacles.
- 2.1.2 Masonry electro-galvanized steel masonry single and multi-gang boxes for devices flush mounted in exposed block walls.
- 2.1.3 Concrete electro-galvanized steel concrete type boxes for flush mount in concrete with matching extension and plaster rings as required.

2.2 Pull and Junction Boxes

- 2.2.1 Provide pull or junction boxes where indicated or necessary to facilitate the pulling of conductors.
- 2.2.2 Provide identification on each box.

2.3 Outlet Boxes

- 2.3.1 Provide each light, switch, receptacle and/or outlet with a suitable outlet box, each approved for the particular area in which it is to be installed
- 2.3.2 Ceiling boxes shall be 100 mm octagon.
- 2.3.3 Switch receptacles, telephone and miscellaneous outlets on exposed conduit work shall be housed in FS boxes with PVC covers.

3. EXECUTION

3.1 Location of Outlet Boxes

- 3.1.1 The indicated outlet locations are approximate; exact locations shall be determined from details and architectural and process drawings or instructions
-

on the job. Allowance shall be made in locating outlets for overhead pipes, ducts and other obstructions. The city reserves the right to change location of outlets to within 3 m of points indicated on plans without extra charge providing the Contractor is advised prior to installation.

- 3.1.2 Where switches, receptacles, are in the same general location, outlets to be lined up vertically unless otherwise called for by the City Project Manager.
- 3.1.3 Locate light switches on latch side of doors. Locate disconnect devices on latch side of door.

3.2 Installation

- 3.2.1 Support boxes independently of connecting conduits.
- 3.2.2 Fill boxes with paper, sponges or foam or similar approved material to prevent entry of construction material.
- 3.2.3 Provide correct size of openings in boxes for conduit. Reducing washers are not allowed.

3.3 Outlet Boxes

- 3.3.1 All outlet boxes in furred area shall be rigidly secured by metal hangers bolted to furring strips. Outlet boxes intended for fixture supports shall be provided with fixture studs where required.
- 3.3.2 All outlet boxes installed in the formwork shall be filled with suitable filler material and shall be properly fastened to the formwork to prevent the outlet box filling with concrete during the pouring.

3.4 Pull and Junction Boxes

- 3.4.1 For concealed conduit make boxes flush with wall, complete with covers, accessible and easily removed.

END OF SECTION

1. **GENERAL**

1.1 **General**

1.1.1 Comply with the requirements of the contract documents.

2. **PRODUCTS**

2.1 **Wall Switches**

2.1.1 15 A, 20 A, 120 V, single pole switches as indicated or where required, manually operated, toggle, specification grade (colour to be advised).

2.1.2 Provide switches of one manufacturer through project where possible.

2.1.3 Acceptable manufacturers:

.1 Pass & Seymour

.2 Arrow Hart

.3 Bryant

.4 Hubbell

.5 Pass & Seymour

.6 Slater

.7 Smith & Stone

2.2 **Receptacles**

2.2.1 Duplex receptacles, CSA Type 5-15R, 125 Volt, 15 A, u-ground, colour to be advised, weather proof where indicated on drawings.

2.2.2 Receptacles of one manufacturer throughout projects, where possible.

2.2.3 Acceptable Manufacturers:

.1 Pass & Seymour

.2 Arrow Hart

.3 Bryant

.4 Hubbell

.5 Pass & Seymour

.6 Slater

.7 Smith & Stone

2.3 **Coverplates**

- 2.3.1 Coverplates for wiring devices in finished areas: stainless steel, type 302 alloy, 0.035 satin finish.
- 2.3.2 Coverplates from one manufacturer throughout project.
- 2.3.3 Coverplates for surface mount wiring devices and blank: Scepter PVC type.
- 2.3.4 Weatherproof duplex receptacle covers: Hubbell Cast Aluminum, Cat. No. 5205 UO.
- 2.3.5 All coverplates below grade to be NEMA 4 (watertight).

3. **EXECUTION**

3.1 **Installation**

- 3.1.1 Not used.

END OF SECTION

1. GENERAL

1.1 General

- 1.1.1 Comply with the requirements of the contract documents.
- 1.1.2 Provide the specified products where shown on schedules, device data sheets or as shown on the Contract Drawings.
- 1.1.3 For each connected motor one horsepower or above, provide a disconnect switch whether or not shown on the drawings. For fractional horsepower motor disconnects use manual motor starters without overloads.
- 1.1.4 Provide all fuses required to complete the installation under this section complete with renewable links of Economy manufacture or approved equal.

2. PRODUCTS

2.1 Equipment Enclosure

- 2.1.1 Compatible with room or area environment and unless otherwise indicated, in accordance with classification specified in Section 16010.
- 2.1.2 Unless otherwise indicated, factory finish all equipment inside and outside with ANSI/ASA #61 grey paint.

2.2 Disconnect Switch

- 2.2.1 Switch
 - .1 Type: Fusible and Non-fusible as indicated
 - .2 Operation: Front-operated, heavy duty, industrial grade, quick-make, quick-break, with provision for padlocking in OFF position.
 - .3 Rating: As required
 - .4 Fuse holders (for fusible switches): For HRC1-J fuses without adapters.
- 2.2.2 Manufacturers:
 - .1 Cutler-Hammer Industrial Controls
 - .2 Square 'D' Canada
 - .3 Siemens Canada
 - .4 Allen-Bradley Canada Ltd.

2.3 Manual Motor Starter

- 2.3.1 Manual motor starters:
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- .1 Type: Single or multi-pole (as indicated), quick-make, quick-break, manual reset, trip indicating handle, with one overload device in each ungrounded phase conductor, toggle operated.
- .2 Integral horsepower manual motor starter: EEMAC size M-1 minimum and to be same type and manufacturer as the MCC.
- .3 Mounting: Flush-mount in concealed conduit areas.

2.3.2 Manufacturers:

- .1 Cutler-Hammer Industrial Controls
- .2 Square 'D' Canada
- .3 Siemens Canada
- .4 Allen-Bradley Canada Ltd.

2.4 Breakers in MCC

- 2.4.1 Automatic Breakers: With adjustable, interchangeable thermal magnetic trip units.
- 2.4.2 Thermal magnetic trips for feeder breaker: Interchangeable except on 100 A and 150 A frame units.

2.5 Local Control Panels, Control Panels

- 2.5.1 Provide local control panels with control and indicating devices as indicated, enclosure to be suitable for the area where the local control panel is located and as indicated on contract documents.

2.6 Magnetic Motor Starters and Contactors

- 2.6.1 Magnetic motor starters: Combination type, full voltage, reduced voltage or multi-speed type, reversing or non-reversing, EEMAC Size 1 minimum, rated for system fault capacity. Intermediate EEMAC sizes not acceptable.
 - 2.6.2 Overload relays: Adjustable, ambient compensated, manually resettable from enclosure door, one element for each ungrounded phase.
 - 2.6.3 Overload relay heaters: Field installed, selected to match installed motor nameplate data.
 - 2.6.4 Contactor: Electrically drawn in and held.
 - 2.6.5 Reversing starters: Contactors mechanically and electrically interlocked.
 - 2.6.6 Circuit disconnecting means: Circuit breaker as indicated.
 - 2.6.7 Fusible switch fuse holders: Suitable for HRC1-J fuses.
 - 2.6.8 Motor starter circuit breaker: Moulded case, with adjustable magnetic only trips. Co-ordinate with thermal overload device.
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- 2.6.9 Mechanical interlock: Prevent opening of door when disconnecting device in ON position.
- 2.6.10 Control transformer: Fused 120 V secondary winding, unfused leg grounded.
- 2.6.11 Manufacturers:
 - .1 Cutler-Hammer Industrial Controls
 - .2 Square 'D' Canada
 - .3 Siemens Canada
 - .4 Allen-Bradley Canada Ltd.

2.7 Ancillary Devices

- 2.7.1 Auxiliary contacts: In addition to contacts indicated, minimum one normally open and one normally closed spare contact, separate poles.
 - 2.7.2 Operator devices: Heavy duty, industrial, oil tight, functions as indicated (pushbuttons, selector switches), rated 120 V AC, wired to terminal blocks, Type K by Square D Canada, Type CR104P by GE Canada, Type PB1 by Cutler Hammer, Type 10250T by Cutler Hammer, Type 800T by Allen-Bradley Canada Ltd.
 - 2.7.3 Indicating lights: Integral transformer type, 12 V secondary, with clustered LED lamps replaceable from front without disconnecting power supply, push to test type.
 - 2.7.4 COMPUTER/LOCAL type selector switches shall be of early-make, late-break type contacts in control circuits for bumpless transfer of device control mode. Switch operation shall be maintained position. One spare set of contacts for each panel.
 - 2.7.5 Emergency Stop Button – Red, mushroom handle, heavy duty mechanically held, three contacts minimum, pull to reset protective cover around handle to reduce accidental operation.
 - 2.7.6 Heater and lighting contactors: Similar to magnetic motor starters, but without thermal overload devices.
 - 2.7.7 Heater and lighting circuit breakers: Moulded case, with integral thermal magnetic trips, interrupting rating 18,000 A RMS symmetrical minimum at 600 V.
 - 2.7.8 Internal power wiring: Stranded copper, minimum #12 AWG, rated 600 V, sized to accommodate largest load starter is capable of switching.
 - 2.7.9 Control wiring: Stranded copper, minimum #14 AWG, 600 V rated. Utilize extra flexible conductors for wiring to panel doors.
 - 2.7.10 Wire identification: Oil-resistant, Type Z markers by Wieland Electric Inc. at conductor ends. Adhesive cloth or Mylar types will not be accepted.
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- 2.7.11 Terminal blocks: Compression type, modular, 25 A, 600 V minimum, identified with numbers identical to wire numbers. Supply six spare terminal blocks minimum.
- 2.7.12 Maximum number of wires under each terminal screw: Two.
- 2.7.13 Wiring and schematic diagram: Permanently mounted inside enclosure.
- 2.7.14 Hazardous area application: Panel and associated devices suitable for application in specific hazardous area. Type EMP by Crouse-Hinds, G Series by Killark Electric Manufacturing Co.

2.8 Control Relays

- 2.8.1 General purpose relays: Heavy duty, industrial, EEMAC rated, electrically held, 120 V AC coil, minimum 10 A, 120 V AC convertible contacts. Manufacturers
 - .1 Allen-Bradley Canada Ltd., Type P
 - .2 Square D Canada, Type X
 - .3 Cutler-Hammer Canada. Type AR
- 2.8.2 Magnetic latching relays: Heavy duty, industrial, EEMAC rated, magnetically or mechanically held, electrically released, 120 V AC coil, minimum 10 A, 120 V AC convertible contacts. Manufacturers:
 - .1 Allen-Bradley Canada Ltd., Type NM
 - .2 Square D Canada, Type XL
 - .3 Cutler-Hammer Canada. Type ARML
- 2.8.3 Timing relays: ON delay, OFF delay or Interval type as indicated, 120 V AC coil, minimum 10A, 120 V AC convertible contacts, knob adjustable timing, timing range as indicated. Manufacturers:
 - .1 Allen-Bradley Canada Ltd., Type PT or NT
 - .2 Square D Canada, Type X
 - .3 Cutler-Hammer Canada. Type ARPT
- 2.8.4 Double voltage relays: Convertible contacts, number and type as indicated, metal barrier between coil and contact terminations, where indicated or required by the Inspection Authorities.
- 2.8.5 Thermistor relays: Type 3UN2100 by Siemens Electric Ltd. compatible with respective motor winding temperature sensors (thermistors).

2.9 Panelboards

- 2.9.1 Supply 208/120V and 600V panelboards from same manufacturer as the Motor Control Centre.
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- 2.9.2 Circuit breaker type panelboards: Deadfront design, equipped with double or single row, bolt-on, thermal magnetic, non-interchangeable, moulded case branch circuit breakers of sizes and types indicated.
- 2.9.3 Ratings: unless otherwise indicated, circuit breaker panelboards and components with the following minimum (symmetrical) short circuit ratings:
 - .1 600 V Power Panelboards 25,000A
 - .2 208/120 V Panelboards 10,000A
- 2.9.4 Busbars: Tin plated copper equipped with solderless lugs for incoming cables where main circuit disconnecting device is not indicated.
- 2.9.5 Doors: With spring latches and cylinder locks keyed alike, two keys per panelboard.
- 2.9.6 Circuit directory: Framed plexiglass enclosed legend, located on inside of door.
- 2.9.7 Lock-on/lock-out devices: For all main and feeder breakers.
- 2.9.8 Isolated ground bus: In designated panels as indicated.
- 2.9.9 Ground fault protection circuit breakers: Class A type, 120 V, automatic shunt trip, facilities for testing and reset.
- 2.9.10 Manufacturers for 208/120V and 600V Panelboards:
 - .1 Square D Canada: NQOB
 - .2 Cutler-Hammer: Pow-R-Line series
 - .3 Siemens Canada

2.10 Distribution Transformers

- 2.10.1 Design: General purpose, high efficiency, dry type, ANN, 60 Hz, low sound level with vibration isolators, rating and voltages as indicated. Four 2½% primary taps (2-FCAN, 2-FCBN).
 - 2.10.2 Insulation: Class 185 °C minimum with maximum 80 °C temperature rise in 40 °C ambient, epoxy encapsulated in damp, hazardous or outdoor areas.
 - 2.10.3 Windings: Copper, delta connected primary, wye connected secondary with neutral grounding provision.
 - 2.10.4 Manufacturers Supply distribution transformers of one manufacture throughout project:
 - .1 Hammond Manufacturing Co. Ltd.
 - .2 ABB Canada
 - .3 MagneTek Polygon Transformer Co.
-

- .4 Square 'D' Canada
- .5 Marcus Transformer of Canada Ltd.
- .6 Rex Manufacturing
- .7 Delta Transformer of Canada Ltd.

2.11 Flashing Lights

- 2.11.1 Non-hazardous areas: 120 V AC, heavy duty, weatherproof, red lens. AdaptaBeacon 97C Series by Edwards, VDAS by Crouse-Hinds, Industrial Strobe by Applied Strobe Technology Co. Ltd., 371DST by Federal Signal Corp.
- 2.11.2 Hazardous areas: 120 V AC, approved for use in specific area, red lens. AdaptaBeacon, 50REX-5 by Edwards, EV Series by Crouse-Hinds, Factory Sealed Strobe by Applied Strobe Technology Co. Ltd., Model 27XST Series B by Federal Signal Corp.

2.12 Horn

- 2.12.1 Non-hazardous areas: 120 V AC, low current, high decibel, vibrating, heavy duty, weatherproof, field adjustable output range, 78-103 dB at 3040 mm, Adaptahorn 876-N5 by Edwards, Vibratone Model 350 by Federal Signal Corp., WH Series by Crouse-Hinds.
- 2.12.2 Hazardous areas: 120 V AC, low current, high decibel, vibrating, 100 dB at 3040 mm. Adaptahorn 878-120 by Edwards, Model 31X by Federal Signal Corp., ETH High Power Horn by Crouse-Hinds.

2.13 Wiring Terminations

- 2.13.1 Lugs, terminals and screws used for termination of wiring to be made of tin-plated copper, except as specified in the detailed specifications, e.g. instrument/control panels.

3. EXECUTION

3.1 Disconnect Switch Installation

- 3.1.1 Provide fusible disconnect switches complete with fuses and store spare fuses kept in original containers in the appropriate storage cabinet.
- 3.1.2 Provide mounting pedestal for units located adjacent to equipment in open areas.

3.2 Manual Motor Starter Installation

- 3.2.1 Flush-mount manual starters in concealed conduit areas.

3.3 Breakers in MCC

- 3.3.1 Mount breakers in MCC's as indicated, provide hardware to suit.
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3.4 Local Control Panel Installation

3.4.1 Mount as indicated on Contract Drawings or Data Sheets.

3.5 Magnetic Motor Starter and Contactor Installation

3.5.1 Connect auxiliary control devices.

3.6 Panelboard Installation

3.6.1 Provide panelboards of type and size indicated.

3.6.2 Terminate and connect field wiring.

3.6.3 For ground fault protected circuits, wire in accordance with manufacturer's recommendation.

3.7 Fuses

3.7.1 Install fuses in mounting assembly before energizing circuit.

3.7.2 Verify fuses physically match mounting devices. Where fuses and holders do not match, replace holder.

3.7.3 Provide size and type of fuses in accordance with Inspection Authority requirements.

3.8 Distribution Transformer Installation

3.8.1 Provide distribution transformers, mounted in upright position, as indicated. Verify wall or ceiling is adequate to support transformer. Provide additional bracing as required.

3.8.2 Install transformer to permit full accessibility to wiring and tap connections. For floor mounted units, allow 150 mm clearance from walls or other equipment to permit adequate ventilation through and around the housing.

3.8.3 Adjust vibration isolators for optimum noise suppression.

3.9 Load Balance

3.9.1 Measure phase current to lighting panelboards with normal lighting loads operating at time of acceptance. Adjust branch circuit connections as required to obtain best balance of current between phases and record changes.

3.9.2 Measure phase voltages at loads and adjust transformer taps to within 3% of rated voltage of equipment.

3.10 Flashing Light and Horn Installation

3.10.1 Adjust as per manufacturer's recommendations.

END OF SECTION

1. GENERAL

1.1 Product Data

- 1.1.1 Submit product data in accordance with Section 16010.
- 1.1.2 Include time-current characteristic curves for breakers with ampacity of 100A and over.

2. PRODUCTS

2.1 Breakers

- 2.1.1 Bolt-on molded case circuit breaker: quick-make, quick-break type, for manual and automatic operation.
- 2.1.2 Common-trip breakers: with single handle for multi-pole applications.
- 2.1.3 Magnetic instantaneous trip elements in circuit breakers to operate only when value of current reaches 10X setting. Trip settings on breakers with adjustable trips to range from 3-8 time's current rating.
- 2.1.4 Circuit breakers with interchangeable trips as indicated.
- 2.1.5 Approved Manufacturers:
 - .1 Cutler-Hammer
 - .2 Siemens
 - .3 Square D

2.2 Thermal Magnetic Breakers

- 2.2.1 Molded case circuit breaker to operate automatically by means of thermal and magnetic tripping devices to provide inverse time current tripping and instantaneous tripping for short circuit protection.
- 2.2.2 Optional Features
- 2.2.3 Include ON-OFF locking devices as indicated.

3. EXECUTION

3.1 Installation

- 3.1.1 Install circuit breakers as indicated.
- 3.1.2 Ensure that all circuit breakers are properly rated and coordinated.

END OF SECTION

1. **GENERAL**

1.1 **Reference:**

- 1.1.1 This Section should be read in conjunction with Section 16551 which shall apply to and govern the work under this section.

1.2 **Shop Drawings and Product Data:**

- 1.2.1 Submit shop drawings and product data in accordance with Section 16551.

2. **PRODUCTS**

2.1 **Source Four LED Series 2:**

- 2.1.1 The Source Four LED Series 2 revolutionizes LED lighting. With optimized arrays and finely tuned electronics, Series 2 offers a combination of light quality and output that cannot be matched.

- 2.1.2 The Source Four LED Series 2 Lustr: luminaires are based on the x7 Color System, utilizing seven colors including high-output lime to achieve true, usable broad-spectrum color with a depth and feel beyond any RGB fixture. Series 2 light engines work with all Source Four lens tubes to deliver a high-quality, controllable beam of LED light. For the best results, we highly recommend that you use EDLT lens tubes. We also offer a special LED-only version of the 50° lens tube. Combine with available adapters to transform your fixture into a fully functional Fresnel or CYC light.

2.2 **Manufacturers:**

- 2.2.1 The Theatrical lighting instruments manufactured by ELECTRONIC THEATER CONTROLS, INC. (ETC), are specified herein to provide a basis of quality. Other acceptable manufacturers are ALTMAN.

2.3 **THEATRICAL LIGHTING INSTRUMENT PACKAGE:**

- 2.3.1 Theatrical lighting instruments shall be capable of performing with light-emitting diodes (LED) as indicated herein with proper heat sink cooling. Phenolic materials shall be employed on the fixtures in order to protect the operator from potential burns.

- 2.3.2 Each theatrical lighting instrument shall be supplied with a malleable iron clamp (c-clamp) to grip up to a two (2) inch ID pipe, and a fixture yoke with locking clutch handle. Each instrument shall be furnished with a power cable (5' PowerCon to Twist-lock type-equipped power cord or PowerCon to PowerCon Jumper Cable), 5' DMX jumper cable, and safety cable. A minimum of 10% of all jumper cables (PowerCon to PowerCon and DMX) shall be provided in 10' lengths.

- 2.3.3 Minimum performance criterion for all theatrical lighting instruments shall be as herein specified. Each instrument shall be furnished with a three pole, grounded stage-pin male connector and safety cable. UL listing shall be required on all theatrical lighting instruments.

2.4 COLOR MIXING LIGHT EMITTING DIODE PROFILE FIXTURE:

- 2.4.1 The fixture shall be a color-mixing high-intensity LED illuminator with DMX control of intensity and color. The fixture shall be a Source Four LED Series 2 as manufactured by Electronic Theatre Controls, Inc. or approved equal.
- 2.4.2 All LED fixtures shall be provided by a single manufacturer to ensure compatibility.
- 2.4.3 The fixture shall be UL 1573 listed for stage and studio use.
- 2.4.4 The fixture shall comply with the USITT DMX-512A standard.

2.5 Physical:

- 2.5.1 The unit shall be constructed of rugged, die cast aluminium, free of burrs and pits, finished in black.
- 2.5.2 Lens secured with silicone shock mounts.
- 2.5.3 Shutter assembly shall allow for +/-25 rotation.
- 2.5.4 20-gauge stainless steel shutters.
- 2.5.5 Interchangeable lens tubes for different field angles with Teflon guides for smooth tube movement.
- 2.5.6 Sturdy integral die cast gel frame holders with two accessory slots, and a top-mounted, quick release gel frame retainer.
- 2.5.7 Rugged steel yoke with two mounting positions allowing 300+ rotation of the fixture within the yoke.
- 2.5.8 Positive locking, hand operated yoke clutch.
- 2.5.9 The housing shall have a rugged black powder coat finish.
- 2.5.10 Power supply, cooling and electronics shall be integral to each unit.
- 2.5.11 The unit shall ship with: Theatrical style hanging yoke as standard.
- 2.5.12 5' Neutrik PowerCon™ to Twist-lock type-equipped power cable as standard.
- 2.5.13 Gate diffuser
- 2.5.14 A-size pattern holder
- 2.5.15 Available options shall include:
 - .1 PowerCon to PowerCon cables for fixture power linking.
 - .2 Smooth Wash Diffuser for overlapping beams of light from multiple fixtures.

2.6 Optical:

- 2.6.1 The light beam should have a 2-to-1 centre-to-edge drop-off ratio.
- 2.6.2 The unit shall provide, but not be limited to: Low gate and beam temperature and Sharp imaging through a three-plane shutter design.
- 2.6.3 High-quality pattern imaging.
- 2.6.4 Sharp shutter cuts without halation.
- 2.6.5 Shutter warping and burnout in normal use shall be unacceptable.
- 2.6.6 Adjustable hard and soft beam edges.

2.7 Environmental and Agency Compliance:

- 2.7.1 The fixture shall be ETL and cETL LISTED and/or CE rated and shall be so labeled when delivered to the job site.
 - 2.7.2 The fixture shall be ETL LISTED to the UL1573 standard for stage and studio use.
-

2.7.3 The fixture shall be rated for IP-20 dry location use.

2.8 **Thermal:**

2.8.1 Fixture shall be equipped with a cooling fan.

2.8.2 Fan speed control via a DMX channel shall be possible.

2.8.3 Fan speed software shall permit the fixture to override DMX fan speed setting to prevent heat damage to the fixture.

2.8.4 The fixture shall utilize advanced thermal management systems to maintain LED life to an average of 70% intensity after 20,000 hours of use.

2.8.5 Thermal management shall include multiple temperature sensors within the housing to include:

- a. LED array circuit board temperatures
- b. Temperature sensors placed on each individual LED colour circuit.
- c. Fixture ambient.
- d. CPU.

2.8.6 Fixture user shall permit monitoring of temperature sensors via a legible LCD multi-line backlit display.

2.8.7 Fixtures that do not provide active thermal monitoring of LED circuits and other temperature readings shall not be acceptable.

2.8.8 The fixture shall operate in an ambient temperature range of 0°C (32°F) minimum, to 40° C (104°F) maximum ambient temperature.

2.9 **Electrical:**

2.9.1 The fixture shall be equipped with a 100V to 240V 50/60Hz internal power supply.

2.9.2 The fixture shall support power in and thru operation.

2.9.3 Power in shall be via Neutrik® PowerCon™ input connector.

2.9.4 Power thru shall be via Neutrik ® PowerCon ™ output connector.

2.9.5 Fixture power wiring and accessory power cables shall be rated to support linking of multiple fixtures up to the capacity of a 15A breaker.

2.9.6 The fixture requires power from a non-dim source.

2.9.7 Power supply outputs shall have self-resetting current-limiting protection.

2.9.8 Power supply shall have power factor correction.

2.10 LED Emitters:

- 2.10.1 The fixture shall contain a minimum of four different LED colors to provide color characteristics as described in the Color Section below.
- 2.10.2 All LEDs used in the fixture shall be high brightness and proven quality from established and reputable LED manufacturers.
- 2.10.3 Fixture shall utilize Luxeon® Rebel™ and/or Osram OSLON Square LED emitters.
- 2.10.4 Manufacturer of LED emitters shall utilize an advanced production LED binning process to maintain color consistency.
- 2.10.5 LED emitters should be rated for nominal 20,000-hour LED life to 70% intensity.
- 2.10.6 All LED fixtures (100% of each lot) shall undergo a minimum three-hour burn-in test during manufacturing.
- 2.10.7 LED system shall comply with all relevant patents.

2.11 Calibration:

- 2.11.1 Fixture shall be calibrated at factory for achieve consistent color and intensity output between fixtures built at different times and/or from different LED lots or bins.
- 2.11.2 Calibration data shall be stored on the LED array as a permanent part of on-board operating system.
- 2.11.3 All arrays, including replacement arrays shall be calibrated to the same standard to insure consistency.
- 2.11.4 Fixtures not offering LED calibration shall not be acceptable.

2.12 Color:

- 2.12.1 The fixture shall utilize a minimum of 60 LED emitters.
- 2.12.2 The fixture shall be the Source Four LED Series 2 Lustr.
- 2.12.3 Red, Amber, Green, Cyan, Blue, Indigo and Lime LEDs in an array designed for broad spectrum color, light tints, and variable whites. This array shall be the Lustr array as manufactured by Electronic Theatre Controls or approved equal.
- 2.12.4 Measured brightness of the Lustr array shall be greater than 6,500 field lumens.

2.13 Dimming:

- 2.13.1 The LED system shall use 15-bit nonlinear scaling techniques for high-resolution dimming.
 - 2.13.2 At least four different dimming curve options shall be accessible at the fixture's User Interface. 1) Incandescent 2) Standard 3) Linear 4) Quick
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- 2.13.3 Dimming curves shall be optimized for smooth dimming over longer timed fades.
- 2.13.4 The LED system shall be digitally driven using high-speed pulse width modulation (PWM).
- 2.13.5 LED control shall be compatible with broadcast equipment in the following ways: 1) PWM control of LED levels shall be imperceptible to video cameras and related equipment. 2) PWM rates shall be adjustable by the user at the fixture if necessary to avoid any visible interference to video cameras and related equipment.

2.14 Control and User interface:

- 2.14.1 The fixture shall be USITT DMX 512A-compatible via In and Thru 5-pin XLR connectors.
 - 2.14.2 The fixture shall be compatible with the ANSI RDM E1.20 standard.
 - 2.14.3 All fixture functions shall be accessible via RDM protocol for modification from suitably equipped control console.
 - 2.14.4 Temperature sensors within the luminaire shall be viewable in real time via RDM.
 - 2.14.5 Fixtures not offering RDM compatibility, feature set access or temperature monitoring via RDM shall not be compatible.
 - 2.14.6 The fixture shall be equipped with multi-line LCD display for easy-to-read status reports and configuration changes.
 - 2.14.7 The fixture shall be equipped with a six-button user-interface.
 - 2.14.8 The fixture shall offer multiple DMX input profile options to include:
 - 2.14.9 RGB - control of all individual LED colors via a three-channel profile: Red, Green, Blue.
 - 2.14.10 HSI – control of all individual LED colors via a three-channel profile: Hue, Saturation, Intensity
 - 2.14.11 HSIC – control of all LED colors via a four-channel profile: Hue, Saturation, Intensity and Color Point
 - 2.14.12 Color point provides variable color temperature settings.
 - 2.14.13 Direct – control of each individual color channel via an independent channel.
 - 2.14.14 Studio – Control of the fixture in a white-light 3 channel profile: Intensity, Color Temperature, +/- Green (Tint)
 - 2.14.15 Without DMX the fixture can master other Source Four LEDs and Desire fixtures that are connected via 5 pin XLR DMX cables.
 - 2.14.16 A variable-rate strobe channel shall be provided.
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- 2.14.17 The fixture shall offer three output settings:
- a. Boost mode - powers LEDs at maximum intensity and provides no compensation against LED 'droop' or intensity loss.
 - b. Regulated mode – slightly restricts maximum LED intensity levels to compensate against LED droop.
 - c. Protected mode – further restricts maximum LED intensity levels to compensate against LED droop and offer color consistency at highest permissible ambient temperatures (40C).
 - d. Fixtures that do not provide regulated and protected operation modes are not acceptable.
- 2.14.18 The fixture shall offer additional user-definable options to including but not limited to:
- a. Display time out options.
 - b. Loss of data behavior options.
 - c. White point settings.
 - d. Red-shift option for tungsten dimming emulation.
- 2.14.19 The fixture shall offer five Quick Set-Ups to allow user to rapidly select different combinations of the numerous user options based on the desired usage situation, to include:
- a. General – for most situations
 - b. Stage – when emulating incandescent fixtures is desired.
 - c. High Impact – when maximum output and effect is desired.
 - d. XT Arch – when color consistency and architectural characteristics are desired.
 - e. Studio - when DMX or stand-alone of white light output is required with intensity, color temperature and color tint control parameters.
- 2.14.20 The fixture shall offer stand-alone functionality eliminating the need for a console.
- a. Fixture shall ship with 24 preset colors accessible as a stand- alone feature.
 - b. Fixture shall ship with 12 sequences accessible as a stand-alone feature.
 - c. Each color and sequence can be modified by the end user.
 - d. Fixtures can be linked together with standard DMX cables and controlled from designated master fixture.1) Up to 32 fixtures may be linked.
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- e. Fixtures in a stand-alone state shall restore to the settings present prior to power cycling, eliminating the need for reprogramming.
- f. Fixtures without stand-alone operation features described above shall not be acceptable.

2.14.21 The fixture shall be capable of copying all performance settings to other fixtures of the same type via a 5 pin XLR DMX cable.

2.14.22 Provide with cyc adapters.

2.15 SOURCE FOUR LED CYC ADAPTER:

2.15.1 The adapter shall work with all Source Four LED light engines.

2.15.2 The adapter shall provide an evenly distributed light output when used in combination across large, flat surfaces.

2.15.3 The unit shall be constructed of rugged, die cast aluminium, free of burrs and pits, as well as injection molded ABS components; finished in black.

2.15.4 Any exposed optics (excludes mirrors) shall be constructed out of heat and impact resistant poly-carbonate material.

2.15.5 The unit shall attach securely to all Source Four LED light engines.

2.15.6 Unit should be able to be placed as close as 2 Ft. from the illuminated surface.

2.15.7 Unit should be able to be top or bottom mounted.

2.15.8 Unit should be able to achieve a 2:1 spacing.

2.15.9 Unit should be able to light a 40 Ft. cyclorama with a top and bottom hang.

2.15.10 Unit should maintain approximately 30% efficiency from source lumens to total field lumen output.

3. EXECUTION

3.1 Installation

3.1.1 All wiring for the house and stage lighting control system shall be run in conduit and flexible multi-conductor cables as hereinbefore specified.

3.1.2 Data wiring for DMX controlled house lights shall be Belden 9729 or equal. Data wiring for house lights must be run in conduit.

3.1.3 All junction box covers shall be identified as hereinbefore specified. All conduit, device mounting boxes, junction boxes, and enclosures shall be securely fastened with appropriate fittings to ensure positive ground throughout the entire system.

3.1.4 This Contractor shall furnish and install all wiring and make all final connections as indicated in the system manufacturer's shop drawings and standard installation documents. Splices for dimming circuits shall be made only in junction boxes.

- 3.1.5 All wiring shall be checked and tested by this Contractor to ensure the system is free from grounds, opens, and shorts.
- 3.1.6 It shall be the responsibility of the Contractor performing the work in this section to coordinate with the stage rigging system Contractor for the proper installation and operation of the stage lighting, wiring devices, cables, supports, etc.
- 3.1.7 All work shall be under the supervision of a field engineering technician, accredited by the system manufacturer. It shall be the responsibility of this technician to check and inspect the installation to the Owner's and Architect/Engineer's satisfaction. This technician shall perform the initial programming of the system with direction and coordination with the Owner.

END OF SECTION