



ALEXANDRA PARK

ELECTRICAL SPECIFICATIONS

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<u>DIVISION 16 - ELECTRICAL</u>	<u>PAGES</u>
SECTION 16010	BASIC ELECTRICAL REQUIREMENTS 15
SECTION 16050	BASIC MATERIALS AND REQUIREMENTS 7
SECTION 16111	CONDUITS 3
SECTION 16112	WIREWAYS AND AUXILIARY GUTTERS 1
SECTION 16120	WIRES AND CABLES 4
SECTION 16125	MINERAL INSULATED CABLE 2
SECTION 16130	OUTLET, CONDUIT BOXES AND FITTINGS 2
SECTION 16135	SPLITTERS, JUNCTION BOXES AND FITTINGS 2
SECTION 16142	WIRE AND BOX CONNECTORS 1
SECTION 16145	WIRING METHODS 1
SECTION 16190	FASTENINGS AND SUPPORTS 2
SECTION 16200	ELECTRICAL HEAT TRACING AND SNOW MELTING 2
SECTION 16365	FUSES 2
SECTION 16410	13.8 KV METAL-ENCLOSED SWITCHGEAR 2
SECTION 16415	1200 KVA POWER TRANSFORMER 2
SECTION 16420	347/600V MAIN SWITCHBOARD 4
SECTION 16440	DISCONNECT SWITCHES 1
SECTION 16450	GENERAL AND SYSTEM GROUNDING 2
SECTION 16460	DRY TYPE TRANSFORMERS UP TO 600V PRIMARY 2
SECTION 16470	PANELBOARDS 3
SECTION 16481	MOTOR STARTERS 3
SECTION 16600	EMERGENCY GENERATOR SYSTEM 5
SECTION 16701	FIRE ALARM AND VOICE COMMUNICATION SYSTEM 14
SECTION 16710	ELEVATOR COMMUNICATION SYSTEMS 1
SECTION 16750	TELEPHONE, SECURITY AND MUSIC SYSTEMS 1
SECTION 16770	DIGITAL METERING SYSTEMS 1
SECTION 16780	GARBAGE OPERATING SYSTEMS 2
SECTION 16790	CO SYSTEM 1
SECTION 16795	NO SYSTEM 1
SECTION 16800	LIGHTING 5
SECTION 16900	FUNDAMENTAL BUILDINGS SYSTEMS COMMISSIONING 9

PART 1 - GENERAL

1.1 General

- .1 Conform to the applicable provisions of Division 1, "General Instruction", the Owners' Standard Form of General Specifications and the Owners' Standard Short Form Contract and the latest Ministry of Housing "Technical Guide for Family Housing" which are hereby considered an integral part of this Specification.
- .2 The whole of the work specified herein, or as shown on the drawings, is intended to comply strictly with the latest edition of the Canadian Electrical Code and the requirements of all the local authorities having jurisdiction.

1.2 Scope of Work

- .1 Refer to Tridel "Scope of Work".

1.3 Abbreviations and Definitions

- .1 The following abbreviations apply to this Division. Any abbreviations not listed will be as defined by ASHRAE.

CESC	-	Canadian Electrical Safety Code
CSA	-	Canadian Standards Association
dB	-	Decibel
°C	-	Degrees Celsius
°F	-	Degrees Fahrenheit
EEMAC	-	Electrical and Electronic Manufacturers' Association of Canada
ft	-	Foot or Feet
hp	-	Motor Horsepower
in	-	Inch or Inches
Kw	-	Kilowatt
mm	-	Millimetre
M	-	Metre
NBC	-	National Building Code
NBS	-	National Bureau of Standards
NC	-	Noise Criterion as Defined by ASHRAE
NEMA	-	National Electrical Manufacturer's Association
NFPA	-	National Fire Protection Association
rpm	-	Revolutions Per Minute
UL	-	Underwriters' Laboratories
ULC	-	Underwriters' Laboratories of Canada
W	-	Watt

- .2 The following definitions apply to this Division:
 - .1 Provide - shall mean to supply and install and pay for.
 - .2 Product - shall mean all materials, equipment, tools, machinery, fixtures and ancillaries.
 - .3 Work - shall mean the total installation to achieve complete and operating systems, including all products, labour costs and services.
 - .4 Tender Documents - shall mean all documents issued with this package and itemized accordingly.

- .5 Contract Documents - shall mean all revisions of the Drawings and Specifications, all Instructions to Bidders, Bid Forms and Contracts.

1.4 Regulations, Codes and Fees

- .1 All work shall be done to the requirements of the authorities having jurisdiction. These are minimum requirements only and the Tender Documents are intended as a supplement.
- .2 Comply with ESA (Electrical Safety Association) electrical bulletins in force at time of Tender submission. While not identified and specified by number of this Division, they are to be considered as forming part of related Ontario Electrical Safety Code 24th Edition/2009 standard. In no instance shall the standards established by the Drawings and Specifications be reduced by any of the Codes referred to above or in other sections of these Specifications.
- .3 Submit to the Consultant and to the Supply Authority the necessary number of drawings and specifications for examination and approval prior to commencement of work.
- .4 Apply, obtain and pay for all permits, fees, connections, inspections, licenses, certificates or charges necessary to complete the Work of this Division.
- .5 Report to the Consultant any changes requested by the authorities. Carry out any changes that do not require extra materials without cost to the Owner.
- .6 Provide any additional documentation requested by the authorities.
- .7 Furnish final Certificate of Acceptance from ESA (Electrical Safety Association).

1.5 Examination of Site & Conditions

- .1 Examine the site, local conditions and Contract Documents prior to submission of Tenders. No allowance will be made later for any expenses incurred through the failure to make these examinations or to report any such discrepancies in writing to the Consultant.
- .2 Make allowance for any new or existing services and equipment relocations necessary to complete the work and include in the Tender submission.
- .3 Make allowance to extend security alarm signals and fire alarm signals to guardhouse. Conduit shall have capacity for future connections.

1.6 Drawings

- .1 All electrical drawings shall form an integral part of this Specification.
- .2 The Drawings show the general intent of the Work, not the details of installation. The Drawings shall be used in conjunction with all other Division Drawings to establish the requirements of routing and installation.
- .3 Obtain all dimensions from field measurement, or from dimensioned drawings if field measurement is not possible. Confirm all dimensions by field measurement prior to installation.
- .4 Provide all changes necessary to eliminate interference.
- .5 Reroute or relocate any system or equipment prior to its installation without cost provided that the change does not increase the total quantity of material.

- .6 Architectural, Structural and Mechanical drawings and specifications shall be read in conjunction with Drawings and Specifications such that the maximum conditions shall govern and be allowed for.

1.7 **Installation Drawings**

- .1 Provide sleeving drawings showing all openings in the structure with all required dimensions. Provide all changes necessitated by the submission of incorrect or late information.
- .2 Provide installation drawings of all work with dimensions drawn to scale of 1:50, and co-ordinate with all Trades and Divisions. These drawings shall show the actual equipment installed all outlets and conduit runs. Completely dimension all openings, recesses and sleeves. Submit drawings as part of as built information at completion of project.
- .3 Provide structural loads with all details necessary for the installation of inserts. Co-ordinate and distribute the loads to match structural capacities. Provide drawings of all concrete construction items, including pads, curbs, sills, basins, anchors, inserts, etc.
- .4 Submit all drawings prior to commencement of the Work. Submit copies of drawings to all Divisions.

1.8 **Shop Drawings**

- .1 Shop drawings shall indicate clearly the materials and/or equipment actually being supplied, all details of construction, accurate dimensions, capacity, operating characteristics and performance. Each shop drawing shall give the identifying number of the item for which it was prepared.
- .2 Each shop drawing for non-catalogue items shall be prepared specifically for this project. Shop drawings and brochures for catalogue items shall be marked clearly to show the items being supplied.
- .3 Each shop drawing or catalogue sheet shall be stamped and signed by the Contractor to indicate that the drawings have been checked for conformance with all requirements of the Contract Documents, that the equipment concerned has been co-ordinated with other equipment to which it is attached and/or connected, and that all dimensions have been verified to ensure the proper installation of the equipment within the available space and without interference with the work of other Trades. Ensure that electrical and all other co-ordination is complete before submission of drawings.
- .4 Installations or manufacture of any product shall not start until after review of shop drawings.
- .5 When requested, shop drawings shall be supplemented by data explaining the theory of operation, which is to be added to the maintenance and operating manual.
- .6 Provide samples of items as requested by the Consultant.
- .7 Shop Drawings required:
 - .1 Main Switchboard and Distribution Panels (include protection coordination and short circuit study).
 - .2 Branch Panelboards.
 - .3 Disconnect switches and Accessories.
 - .4 Luminaries and Lighting Controls including occupancy sensors.
 - .5 Fire Alarm Equipment and Services.
 - .6 Distribution Transformers.
 - .7 Security System Equipment and Devices.
 - .8 Emergency generator and transfer switch.
 - .9 Electric heating and snow melting systems.

- .10 Short circuit calculations and relay coordination study of the entire power system from service entrance onwards; including the customer-owned high voltage equipment.

1.9 Record Drawings (As-built Drawings)

The Engineer will provide this trade with an extra set of white prints on which they shall show clearly in red ink, as the job progresses, all changes and deviations from location on plans. On completion of the work this trade shall provide to the Engineer two complete sets of drawings showing the exact location of all equipment, piping, etc., both inside and outside the building with dimensions to fixed reference points. These drawing shall be drawn to the same standard as the original contract drawings in AutoCAD format.

1.10 Warning Signs

- .1 Provide warning signs as specified or to meet requirements of Inspection Department and Consultant.
- .2 Use prefabricated signs, minimum 175 x 250 mm (8" x 10") in size.

1.11 Products, Materials and Charges

- .1 Products shall be new and free from all defects.
- .2 Products not specifically specified shall be of a quality consistent with the remainder of the Specifications.
- .3 All products shall bear the seal of approving agencies as required by the authorities having jurisdiction.
- .4 All products of one type shall be by the same manufacturer.
- .5 Products to be of same manufacturer and characteristics as base building.
- .6 Where items of equipment, and/or materials, are specifically identified herein by a manufacturers' name, model or catalogue number, only such specification items maybe used in the Base Bid, except as herein provided.
- .7 If any bidder wishes to use in his Base Bid items of equipment other than those specified, he shall obtain the Engineers' written approval of such substitution prior to submission of the Tender.
- .8 Any bidder may, in addition, at the time of tendering, submit for review, materials or products of his choice as alternate to the items called for on the drawings and in specifications. Such alternative tender proposals must be accompanied by a statement of the amount of addition to, or deducted from, the Base Bid amount if the alternate is accepted.
- .9 Alterations from the drawings or specifications shall not be made unless the Contractor has written authorization for the change, and no claim for an addition to, or deduction from the Contract Sum shall be considered unless so ordered.
- .10 All materials required for the completion of the work shall be new and the best of their respective kinds, and of uniform pattern throughout.

1.12 Manufacturers and CSA Labels

- .1 Manufacturers nameplates and CSA labels shall be visible and legible after equipment is installed.

- .2 In public areas no manufacture's nameplates or symbols to be visible on equipment.

1.13 **Alternatives and Substitutions**

- .1 No substitutions shall be made without written approval.
- .2 Any alternatives suggested shall be accompanied by all data required to evaluate the alternative. Alternatives shall be accepted only at the direction of the Consultant.
- .3 The Contractor shall be responsible for the performance and extra cost or liability of all substitutions and alternatives.

1.14 **Protection**

- .1 Protect all equipment from weather and construction debris until substantial completion is acknowledged and building is turned over to Owner.
- .2 All concrete pours shall be made only when under direct supervision of Electrical Contractor's qualified personnel.

1.15 **Load Balance**

- .1 Measure phase current to panelboards with normal loads operating at time of acceptance. Adjust branch circuit connections as required to obtain best balance of current between phases and record changes.
- .2 Measure phase voltages at operating loads and adjust transformer taps to within 2% of rated voltage of equipment.
- .3 Each existing panelboard with modified operating loads shall be adjusted and all branch circuit connections be adjusted, as required, to obtain best balance of current between phases. Record changes.

1.16 **Fireproofing**

- .1 Where cables or conduits pass through floors and fire rated walls, pack space between wiring and sleeve full with an approved compound to meet required fire separation.

1.17 **Construction and Use of Equipment**

- .1 Equipment shall not be used for construction purposes without written permission.
- .2 If equipment is used for construction purposes it shall be returned to as-new condition prior to hand over.
- .3 The Contractor shall accept all costs and liabilities of the construction use of any equipment.

1.18 **Connection of Equipment**

- .1 Provide all connections required by the equipment supplied by this Division.
- .2 Provide all connections required by equipment supplied by the Owner or by other Divisions. Examine all Drawings and Specifications and identify all requirements prior to rough-in.
- .3 Provide all necessary accessories to make connections, including flexible connectors, etc.

1.19 **Certification**

- .1 Provide manufacturer's written certification of the installation and operation of all systems and major equipment.

1.20 **Warranty**

- .1 Provide a written warranty for all materials, equipment and labour for a two-year period, such warranty to take effect from the date the work is designated acceptable by the Consultant.

1.21 **Premium Time**

- .1 Provide in the Tender price any cost for premium time outside of normal working hours to complete the work on schedule and to maintain all electrical systems in operation.

1.22 **Valuation of Changes**

- .1 Provide a complete itemised breakdown of material and labour for each change at net cost. Unit Prices for material as agreed between the Contractor and Owner and N.E.C.A. Column 1 for labour hours.
- .2 No additional money over and above the contract price will be paid for extra work unless a written order, countersigned or otherwise approved by the Consultant, for such work is given.

1.23 **Co-ordination**

- .1 Co-ordinate the Work of this Division with that of all other Divisions.
- .2 Co-ordinate the Work of this Division with all other Divisions for locations of openings, spaces, services, sleeves, supports, connections, etc.

1.24 **Workmanship**

- .1 Only first-class workmanship will be accepted, not only with regards to safety, efficiency, durability, etc., but also with regards to the neatness of detail. All conduit and wiring (NOT ENCLOSED WITHIN FLOOR SLABS) must be lined up parallel, or at right angles to the building walls. Equipment must be accurately alignment. In general, the entire work shall present a neat and clean appearance upon completion.
- .2 It is to be clearly understood that any unsatisfactory work shall be rectified by this Division at its own expense. This Division shall pay the cost of all trades that may be affected by its work or correction.
- .3 The entire work shall be executed using only specified material and apparatus, except where the words, "or approved equal" occur.
- .4 The listing herein of any article, material, operation or method requires that this Division supply all items listed of quality noted and quantity required, and perform such operations according to the methods prescribed supplying all necessary labour and accessories.
- .5 All equipment, wiring and wiring devices shall conform to the Canadian Electrical Code for the purpose for which they are to be used. All equipment shall be C.S.A. approved.
- .6 Materials are specifically described and named for the purpose of establishing a standard of materials and workmanship to which this Division shall adhere and the Contract Price submitted shall be based on the use of the material and equipment specified herein.

- .7 Where the words "or approved equal" occur, this division may use materials other than they specified providing that the Engineer approves the make and quality of the material suggested.
- .8 Should this Division desire to quote on the alternate materials or equipment, it must include in the Tender, the name of the manufacturer or supplier, a complete description of the substitute materials, and any difference in price estimate for each substitution.
- .9 Materials not specified shall be of a high quality, equivalent to other materials which are specified.
- .10 There is no obligation on the part of the Owners or the Engineers to find defects in materials and workmanship at the date of installation. Defects may be found at any time during the construction period or the guarantee period.

1.25 **Extras**

- .1 Should additional work be required, beyond the scope of this Contract, this Division shall submit a quotation, in writing, outlining the nature of the work and itemized breakdown costs of labour and material.
- .2 It must be clearly understood that no "extra" will be recognized for payment, unless the work has been quoted on, and a written order obtained from the Owner/Architect.

1.26 **Shutdowns**

- .1 Maintain all electrical services to all parts of the building which are in use.
- .2 Provide temporary services as necessary.
- .3 Co-ordinate all work with the building Owner or his representative.
- .4 Request and obtain from the building Owner, in writing, permission to interrupt services not less than two (2) weeks in advance and state time(s) and duration(s) of interruption(s).

1.27 **Installation Requirements**

- .1 Install all products and services to follow building planes. Installation shall permit free use of space and maximum headroom to the satisfaction of the Consultant.
- .2 Confirm the exact location of fixtures, outlets and connections. Confirm location of connection points for equipment supplied under other Divisions.
- .3 Install all equipment and appurtenances to allow free access for adjustment, maintenance and/or replacement.
- .4 Install metering and/or sensing devices to provide accurate readings of quantities being measured and in a location that permits easy observation.
- .5 Provide all hangers, supports and fasteners such that no undue stresses are imposed on the structure and systems. Ensure that the load onto structures does not exceed the maximum loading per square metre (foot) as shown on structural drawings.
- .6 Install all products and services in accordance with the respective manufacturer's recommendations.
- .7 Explosive activated tools shall not be used.

- .8 Provide caps and seal all open ends of installed piping, ductwork and conduits to prevent the entrance of foreign substances.
- .9 Install all services capped for future possible use such that easy access is provided for future connections.

1.28 **Field Review**

- .1 The Consultant and Owner shall have access to the site at all times for review of the work.
- .2 Correct any deficiencies as they are reported during the performance of the Work.

1.29 **Salvage Materials**

- .1 Unless noted otherwise, obtains permission from the Owner and remove from the site all materials which are not to remain or be reused.

1.30 **Maintenance Manuals**

- .1 Provide 3 complete sets of hardcover, index, manuals containing the following:
 - .1 List of manufacturers and suppliers names and phone numbers.
 - .2 Catalogue description of each of the following systems:
 - .1 Main Switchboard and Branch Panelboards (include relay protection, coordination and short circuit study).
 - .2 Disconnect Switches and Fuses.
 - .3 Main Distribution Panels.
 - .4 Electric Heating, Ramp Heating and Pipe Tracing.
 - .5 Fire Alarm System.
 - .6 Lighting Fixtures.
 - .7 Security Alarm.
 - .8 Emergency Generator & Transfer Switch.
 - .3 Maintenance and operating brochures for each system:
 - .1 Fire Alarm System.
 - .2 Security Alarm System, Controls.
 - .3 Emergency Generator.
 - .4 Switchboard.
 - .4 Written two year guarantee.
 - .5 Final Hydro/ESA Certificate.
 - .6 List of items turned over to Owner.
 - .7 Provide a report on when, who and what systems the Owners were instructed.
 - .8 Submit a copy of grounding result.

1.31 **Testing**

- .1 Grounding Test
 - .1 Megger circuits, feeders and equipment up to 350 V with a 500 V instrument.

- .2 Megger circuits, feeders and equipment between 350 V - 600 V with a 1000 V instrument.
- .3 Check resistances to ground to be within specification before energising.
- .4 Issue report.
- .2 Distribution Test
 - .1 Check and record the voltage and amperage at each distribution panel, branch panelboards, transformer and motor control centre.
 - .2 Issue report in manuals.
 - .3 Test to ensure all phase rotations are correct.
- .3 Infra-red Scanning
 - .1 Ninety days prior to the expiry of the manufacturers' and this Contractors' warranty on the major electrical devices and components, this Contractor shall provide an infra-red scanning report.
 - .2 The scanning shall be inspected with an infra-red Fast Scan Thermal Imaging camera with video tape capabilities as well as facilities for taking black and white infra-red thermograms of all hot spots encountered and temperature differences.
 - .3 The infra-red inspection shall include equipment, joints and connections on the following equipment:
 - .1 Main switchboards
 - .2 Distribution power panels
 - .3 Disconnect switches, splitters and meter centres
 - .4 An infra-red report, signed by a Professional Electrical Engineer or Certified Thermographer complete with 35 mm colour photographs, black and white thermograms of all hot spots and suggested recommendations for repair shall be submitted within two weeks of scanning to the owners and copy engineers.
 - .5 The report/scan shall be provided by ENERSCAN Controls or approved reputable firm.

1.32 **Liability**

This Contractor shall:

- .1 Assume full responsibility for layout the sub-contractors work and for any damages resulting from improper location or performance of this work.
- .2 Supply to other trades any equipment to be built-in by them or measurement to allow necessary openings to be left.
- .3 Protect all work from damage. Cover floors and other work with tarpaulins, if necessary. Repair all damage to floor surfaces or other parts of the building resulting from execution of the work for this Division, to the satisfaction of the Owner.
- .4 Be responsible for the condition of all materials under this Division and provide all necessary protection and maintenance of the work of this Division until the building has been completed and accepted.

- .5 Be responsible for loss/damage of materials or equipment supplied under this Division and delivered to the site from whatever source.

1.33 Other Trades

- .1 Before tendering, this Division shall examine the existing conditions at the site, the Architectural, Structural and Mechanical Drawings, and shall make himself familiar with the building construction, architectural finishes etc., in order that the price may include everything necessary for the complete installation of the work.
- .2 This Division shall confer with other Divisions installing equipment which may affect its' work and shall arrange its equipment in proper relation with the other apparatus, the building construction, and with the architectural finish. Special care shall be taken in the installation of all equipment where same is concealed to see that it comes within the specified or prescribed finished lines of floors, walls and ceilings.
- .3 This Division shall co-operate with other trades as required for the satisfactory completion of the work.

1.34 Permits and Inspections

- .1 The whole of the work specified herein, or as shown on the drawings, is intended to comply strictly with the latest edition of the Canadian electrical Code, The Ontario Electrical Code, requirements of the Ontario Building Code and of the local Municipality having authority.
- .2 In case of doubt as to the interpretation of the Code, the local ESA Inspector shall be consulted and his decision shall be final.
- .3 This Division shall, upon being awarded this Contract, immediately submit the required number of copies of specifications and drawings to the ESA of Ontario, Inspection Department, for approval prior to commencing any of the work. At the same time, it shall also submit the necessary copies to the local P.U.C., the Bell Telephone Company and Cable TV Company for their approval and information.
- .4 This Division shall also submit to the Engineer, a copy of the complete distribution system which has been approved by the ESA (Electrical Safety Authority).
- .5 This Division shall be held fully responsible for any extra costs incurred by its failure to comply with the above.
- .6 All blueprinting costs and fees for the examination of these specifications and drawings shall be paid for by this Division.
- .7 This Division shall furnish all usual certificates needed as evidence that the work conforms with the laws and regulations of the above listed authorities having jurisdiction before final payment of the Contract is made.
- .8 All charges for permits, inspections, licenses, examination and fees required including heating permits shall be paid for by the Division.

1.35 Instructions to Owners

- .1 Provide qualified technical personal to instruct the Owner's representative in the operation and maintenance of each system.
- .2 Issue a report on when, who and what systems the Owners were instructed.

1.36 **Labels**

- .1 Provide lamacoid nameplates that are a combination glue and mechanically attached. Lamacoids to be a black background with white (minimum 3/8" high) engraved letter.
- .2 Labels to name item, voltage and source of power.
- .3 Labels to be provided on distribution panels, branch panelboards, disconnects, splitters, transformers, starters, motor control centres, dimmer boards and major systems components.
- .4 Provide nameplate wording for approval prior to manufacture.
- .5 On the inside face of each outlet or junction box cover plate, identify what the system is or circuit number with a felt marker. Identify all branch power wiring with circuit tags at outlet end.

1.37 **Sprinklerproof**

- .1 All electrical equipment exposed to sprinklers to be sprinkler proof e.g. distribution panels, branch panels, starters, motor control centres, disconnects, transformers, etc.

1.38 **Plywood Backboards**

- .1 Provide 19 mm good one side, fire rated fir plywood complete with 2 coats of fire retardant paint, equal to CGSB spec. #1-GP-151M, of a colour selected by the consultant for mounting of 2 or more electrical components, e.g., panels, starters, disconnects, telephone terminations, data/voice cables termination, etc..

1.39 **Equipment Identification**

- .1 Identify remote controls for all pertinent equipment.
- .2 All boxes and conduits shall be colour coded. Boxes shall be painted inside and outside. Conduits shall have 19mm bands every 15 meters and both sides of walls.

Colour Coding

Colours shall be as follows:

120/208 volt normal power	-	natural conduit
347/600 volt normal power	-	black
120/208 volt emergency	-	natural/orange
347/600 volt emergency	-	black/orange
fire alarm	-	red
emergency voice communication	-	yellow
telephone	-	green
cable TV	-	grey
security & CCTV	-	blue
isolated power	-	orange
data	-	white
misc. systems	-	purple

- .3 Junction box, pull boxes, outlet boxes shall have circuit, zone, system identification numbers written on the covers with a contrasting colour felt tipped marker pen.

Receptacle covers have the circuit numbers made with self adhesive electronic label makers affixed to the bottom of the cover plates.

- .4 Single conductor cables shall have the neutral identified with white tape and the phase conductors with red and blue tape at both ends, at 15 meter intervals and on both sides of walls and floors.
- .5 All panel directions shall be typewritten and all other equipment shall be identified by means of "Lamacoid" nameplates with white lettering, screwed or riveted on.

1.40 **Protection**

- .1 Protect all finished and unfinished Work of this and other Divisions from damage.
- .2 Keep equipment dry and clean at all times and cover openings in equipment and materials.
- .3 Make good any damage to walls, floors, ceilings, woodwork, brickwork, finishes, etc., however caused.
- .4 Make good to as new quality, or replace, any damaged equipment, as directed by the Consultant.

1.41 **Final Cleaning**

- .1 Do final cleaning.
- .2 At time of final cleaning, clean lighting reflectors, lenses, lamps and other lighting surfaces that have been exposed to construction.
- .3 Clean and touch up surfaces of shop-painted equipment scratched or marred during shipment or installation, to match original paint.
- .4 Clean, prime and paint exposed hangers, racks, fastenings to prevent rusting.

1.42 **Concrete, Excavation and Backfill**

- .1 All concrete, excavation and backfill work required for the electrical division shall be done by the electrical Division 16. Refer to materials listed under 'Site Work', Division 2 & 3.

1.43 **Drip Pans**

- .1 Where pipes pass through electrical and telephone rooms, Division 15 will provide approved pans around the pipes. Co-ordinate locations with Division 15.

1.44 **Noise and Vibration**

- .1 All equipment supplied and/or installed by this Division shall operate without objectionable noise or vibration to the satisfaction of the Owners or his representative.
- .2 All conduit connections to transformers shall be flexible metal type to allow for vibration isolation. Rigid conduits connected to transformers are not acceptable.
- .3 This Division shall be responsible for changes and/or additions necessary to eliminate such objectionable noises and vibrations without extra cost to the Owners.
- .4 All holes and sleeves for conduits and cables shall be tightly packed by means of Rockwool insulation. Where conduit or cables are rigidly installed and no movement is required, holes and sleeves may be filled solid by means of a non-shrink concrete grout.

- .5 Where a penetration through a fire rated wall or floor slab is required, this Contractor shall provide sealant, caulking or fire retardant material to maintain the integrity of the fire separation to the satisfaction of the authorities having jurisdiction and the Engineer.

1.45 **Sleeving**

- .1 This division shall provide all sleeves, inserts, hangers, etc., required for his or his sub-contractors work and shall be responsible for their being securely placed in the correct locations.

1.46 **Expansion and Contraction**

- .1 Proper allowance shall be made for thermal expansion and contraction of all conduits, etc. which shall be installed in such a manner that the strain and weight does not come upon connections and fittings, etc.

1.47 **Grounding**

- .1 All electrical and signal systems under the jurisdiction of this Division shall be grounded in strict accordance with the latest rules and regulations of the E.S.A. of Ontario and the Canadian Electrical Code.
- .2 Only approved grounding conductors and connections shall be used.

1.48 **Workshop**

- .1 This Division shall provide its' own workshop, tool shop and storage space equipped with heat, light and telephone. This Contractor shall be responsible for any losses or damages.

1.49 **Concrete Work**

- .1 All concrete work required for Electrical Sub-Contractors' work shall be provided by the General Contractor. (For lighting standard bases, transformer base, conduits, and ducts, etc.)

1.50 **Temporary Site Services**

- .1 All temporary site services shall be provided by the General Contractor.
- .2 This Contractor shall include in his Tender for providing and maintaining all temporary electrical services throughout the project.
- .3 Provide a suitable 600 volt, 3 phase service for operating a crane, one climber and one-equipment elevator.
- .4 Supply and install a 120/208 volt, 3 phase, 4 wire service of adequate capacity for all temporary lighting throughout the building and for various trades' power tools, welders, temporary heating, etc.
- .5 Supply, install and maintain during the whole of the construction period, temporary lighting in all corridor, stairwells, and public areas, including relamping when necessary.
- .6 Supply and install on every third floor a service panelboard of 100 amp. capacity.
- .7 The wording (temporary electrical services) means the complete installation, supply and maintenance of services, metering, feeders, sub-feeders, branch circuit wiring, switchgear, panelboards, wiring, devices, lamps and all necessary connections.

- .8 The Electrical Sub-Contractor will be held responsible for maintaining all electrical services in safe operating form at all times.

1.51 **Wiring for Other Trades**

In general, unless specifically noted otherwise, the Electrical Division will:

- .1 Wire all motors, duct heaters, water heaters, etc.
- .2 Install and wire all starting equipment and line voltage interlocking wiring, whether built-in or loose.
- .3 Provide, install and wire double voltage relays where required to complete the control system.
- .4 Provide, install and wire disconnects for all equipment, whether shown or not.
- .5 Provide power wiring for boilers, water heaters and furnaces.
- .6 Supply and install an emergency stop button at each boiler room door, wired to the control circuits of all boilers.
- .7 Provide 120 volt outlets for thermostatic controls.
- .8 Wire sprinkler flow alarm switches, supervised valves and sprinkler pressure switches. (Refer to Mechanical drawings for exact locations).
- .9 Wire time switches and contactors supplied and installed by other Divisions.
- .10 Electrical Contractor shall ensure that equipment supplied by other trades is of proper capacity and voltage.

1.52 **Work and Equipment Included**

- .1 This Sub-Contractor shall furnish, receive, assemble, install, connect and adjust for operation, all electrical equipment specified and as shown on the drawings.
- .2 To avoid misunderstanding concerning the work to be executed by the Electrical Sub-Contractor and the work of other trades, it shall be definitely understood that in all cases pertaining to mechanical equipment, the Electrical Sub-Contractor shall do all field wiring required to motors, starters, disconnects, thermostats and controls, unless noted or specified otherwise. He should therefore, read carefully the specifications of these other trades to ascertain the extent of this work.
- .3 In addition, this Sub-Contractor shall supply the following equipment and perform the following services for the mechanical trade:
 - .1 Unless otherwise noted on the drawings, all 120 volt wiring for equipment of mechanical trades shall be supplied and installed by the Electrical Contractor.
 - .2 All unfused disconnect switch shall be supplied and installed by this Sub-Contractor for all motors and equipment.
 - .3 This Sub-Contractor shall be responsible for determining the quantities of material and equipment from the drawings, specifications and by site inspection.

1.53 **Work and Equipment Not Included**

- .1 Motor drives will be furnished and installed by others with the driven equipment.
- .2 Any equipment indicates as "Future" on the drawings, is not part of this Contract.
- .3 float switches, starters and thermostats will be supplied by other Divisions, unless otherwise noted.
- .4 Automatic temperature control wirings, low voltage control wiring interlock wiring for heating system (boilers) and air conditioning systems.
- .5 Security devices supplied and installed by the security contractor.

PART 1 - GENERAL

1.1 WORKED INCLUDED

- .1 Provide complete systems, including all necessary labour, services, products, materials and equipment as shown on the Drawings, listed in the Schedules and as specified herein.

1.2 REFERENCE STANDARDS

- .1 Provide all work in accordance with all applicable codes and to the requirements of all local authorities having jurisdiction, including all applicable by-laws.

PART 2 - PRODUCTS

2.1 CUTTING & PATCHING

- .1 Provide all cutting and patching of existing work or any made necessary by not informing other Trades of the need for any cutting and patching.
- .2 Patch and seal all floor and wall openings with fire resistant insulation and mastic.

2.2 METALS

- .1 Provide all miscellaneous metal required to install the work of this Division.

2.3 ACCESS PANELS DOORS

- .1 Provide all access panels and doors required for the work of this Division.

2.4 UNDERGROUND CABLE DUCT BANK

- .1 Supply and install underground concrete encased duct banks for cables indicated.
- .2 Where concrete work, trenching and back filling is carried under other Divisions of the specifications it shall be this Division's responsibility to supervise the work and to make sure that the work is carried out as specified herein.
- .3 Duct banks shall follow general route shown on the drawings and shall terminate at specified locations. Exact location of duct banks and terminating points shall be verified on the site prior to commencement of work.
- .4 The duct bank shall consist of paralleled ducts encased in concrete. The number and arrangement of ducts shall be as shown on the drawings.
- .5 Ducts shall be C.S.A. certified Type EB1 polyvinyl for concrete encasement or Type DBII for direct burial, with an internal diameter of four inches minimum unless otherwise shown on the drawings.
- .6 Bends shall generally be as factory supplied of approved radius. Radius of such bends shall not be less than standard for the (4") 100mm duct (36") 900mm.
- .7 The duct lengths shall be joined together with an approved coupling to provide a sound joint. Adjacent couplings shall be staggered by at least eight (8) inches. Joint solvent shall be used to seal the couplings.
- .8 Where trench is dry and firm, no bed shall be required; where trench is wet, supply and install a 6" (150mm) layer of crushed stone in the bottom. No concrete shall be poured in trenches containing water.

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- .9 The ducts shall be laid with a minimum spacing of six (6) inches (150mm) centre to centre, both horizontally and vertically for 4" (100mm) ducts; for larger ducts spacing shall be increased correspondingly. Spacers shall be installed on 10 foot (30m) centers and within 24 (600mm) inches of each coupling used. Spacers shall be specially formed plastic. Wood spacers shall not be used.
 - .10 The ducts shall be on even grade slope not less than 1 in 400 in direction indicated on the drawings.
 - .11 The top surface of the concrete encasement shall be a minimum of thirty (30) inches (750mm) below finished grade, unless otherwise indicated on the drawing but in no case shall it be less than twelve (12) inches (300mm) to the finished grade or surface.
 - .12 No ferrous metal shall be installed between primary cable ducts. Re-enforcing shall be installed only near bottom of duct unless specifically indicated otherwise or required by a local hydro authority.
 - .13 Where the duct bank is constructed over recent fill or unstable ground or passes through walls or footings or under driveways or parking lots, the concrete shall be reinforced with 5/8 inch (16mm) diameter Hi-Bond steel bars laid longitudinally at six (6) inches (150mm) lateral spacing and set at 2/3 the depth of the concrete envelope below the bottom row of ducts.
 - .14 All reinforcing rods used shall have a minimum length of six (6) feet (1.8m). Individual lengths of re-enforcing rods are to be overlapped by a minimum of twelve (12) inches (300mm) and is to extend at least 3 feet (1.0m) onto solid ground. In all cases where the duct bank enters a building it shall be reinforced for a distance of eight (8) feet (2.4m) outside the building. Duct bank passing beneath or through building footings, under highways, streets, roads or heavily traveled driveways shall be reinforced and re-enforcing shall extend a distance of five (5) feet (1.5m) beyond in both directions.
 - .15 The ducts shall be encased with minimum 2,500 p.s.i. concrete with a minimum cover of three (3) inches (75mm) on all sides. The concrete shall have a slump of 4 inches (100mm) to 6 inches (150mm) and be of pea gravel aggregate.
 - .16 To prevent any displacement of the duct structure during pouring the duct structure shall be braced down every 10 feet (3.0m) and the concrete shall be deflected down alongside the ducts to the bottom and up through the duct assembly.
 - .17 When crossing other utilities the concrete duct encasement shall maintain a minimum of six inches (150mm) vertical clearance. When running parallel to another utility the duct bank shall be a minimum of five feet (5') (1.5m) clear of said utility but in no case shall it be installed in the same excavation.
 - .18 When completed the ducts shall be cleaned and the ends plugged with duct plugs. The ducts shall be tested for clearance by pulling a steel wire brush and a 3-3/4" (95mm) mandrel through their complete length.
 - .19 Ducts installed for P.U.C. cables and ducts left as spare shall have on continuous length of 3/8" polyethylene rope installed in each duct to facilitate the installation of the cables in the duct. Termination points, grades and route of duct bank shall be confirmed by the P.U.C. on site.
 - .20 Notify the Engineers, Toronto Hydro, ESA, local P.U.C. - at least 48 hours before concrete is poured to permit inspection of the duct installation.
 - .21 Assume responsibility to have the ducts inspected by the Inspection Office and P.U.C. (where applicable) prior to pouring of concrete and again prior to backfilling.

2.5 WIRING OF ITEMS SUPPLIED BY OWNERS

- .1 Completely wire and connect all items listed as supplied by Owner; refer also to the Architectural Drawings. These items will be installed in place by other Divisions but this Division shall do all electrical work required for installation of these items, including control wiring.

2.6 WIRING FOR ILLUMINATED SIGNS

- .1 Exterior illuminated signs will be supplied and installed by Sign Installer. Wire to and connect each of the signs, the location of outlets shall be verified with the Architect before installation. Obtain roughing in drawing from Architect.
- .2 Interior illuminated signs shall be supplied under other Division but shall be installed and completely wired by this Division.
- .3 For each illuminated sign supply and install a disconnect switch at the sign (weatherproof disconnects where required).

2.7 MOUNTING HEIGHT AND OUTLET LOCATION

- .1 The location of outlets and equipment is subject to change without extra cost to the Owner, providing information is given prior to installation. No extra amount will be paid for outlets or equipment relocated requiring extra labour and materials up to 10 feet (3.0m) from the original location, nor will credits be anticipated where relocations up to 10 feet (3.0m) reduces the materials and labour.
- .2 Unless dimensioned, symbols on the drawings show approximate locations only. Care shall be used to locate each fixture at the centre of spaces or rooms and to align continuous rows of fluorescent fixtures.
- .3 Location of outlets in public areas or generally in any corridor, lobby, or in any areas having decorative wall finishes such as glazed tile, mosaic tile, marble, wood paneling, prefabricated panels, etc., shall be confirmed with the Architect prior to installation.
- .4 Where outlets are located within 5'-0" (1.5m) of a mechanical device such as a thermostat, co-ordinate with the Mechanical Trade to ensure that the items are located to approval of the Architect.
- .5 Outlets shall not be mounted halfway through a ceramic or glazed tile dado line. If necessary, the mounting height specified shall be adjusted and the outlet located above the dado line.
- .6 Outlet boxes intended for wall receptacles, switches, telephone outlets, etc., located in exposed concrete block, brick walls or ceramic tile walls shall be saw-cut into the top or bottom edge of the nearest course of block, brick or tile at a height nearest the specified elevation, and the height shall be uniform throughout the project. Opening shall be of minimum size required to take the outlet box and such that the device cover plate will conceal the cut.
- .7 Where a number of outlets are located side by side, their centre lines shall be aligned horizontally. Where outlets occur one above the other, their centre lines shall be aligned vertically. In each case the distance between cover plates shall be 1" (25mm).
- .8 Final roughing-in locations of all floor outlets shall be obtained from the Architectural furniture and equipment layout drawings.

- .9 Receptacles in counters or furniture shall be mounted as detailed on Architectural Drawings.
- .10 Outlets in kitchen shall be mounted at various heights and in locations shown on kitchen roughing-in drawings. Locations shown on electrical drawings are for pricing only.
- .11 Obtain mounting heights from the Architect for all outlets that do not have mounting height indicated.
- .12 All measurements listed, unless otherwise noted, refer to centre line of device from finished floor.

2.8 CIRCUITING OF OUTLETS

- .1 Each outlet shown on the drawing shall be connected to the power or lighting panel indicated. Outlets with same branch circuit number shall be connected to the same branch circuit breaker. Outlets without circuit number designation shall be connected to a spare circuit breaker in the nearest power or lighting panel as required. Normal or emergency in accordance with the nature of the service required. Circuit number shall correspond to breaker number in panel.
- .2 Circuit numbers also show grouping of outlets connected to any given circuit. Circuit numbers may be changed only where required to balance loads in a panel.
- .3 Common neutral may be used for circuits on different phases where code permits. Separate neutrals shall be provided for dimmed circuits and circuits connected to ground fault protected circuit breakers and circuits with isolated ground.

2.9 ELECTRICAL WIRING FOR MECHANICAL DIVISION

- .1 Division 16 will be supplied with electrical motors, starters, controls, relays, float switches, pressure switches, flow switches, pilot lights, remote control stations, safety devices, control transformers, disconnects for control circuits and interlocks where such are supplied with Division 15 equipment.
- .2 Division 16 will mount the above equipment, except for low voltage wall thermostats which shall be mounted by Division 15, complete with enclosures suitable for the application. Exception: Installation of in suite thermostats for fan coil units by Division 16.
- .3 Division 16 shall supply and mount isolation switches where and as required for safe servicing of motors, as well as at electrical panels of all factory assembled package equipment, e.g. rooftop units, condensing units, air conditioning units, humidifiers, exhaust fans, make-up air units etc.
- .4 The isolation switch shall be located within sight of and not more than 7.5 meters from the motor and the machinery driven by the motor.
- .5 Unless otherwise indicated division 16 shall provide power wiring as defined herein.
- .6 Division 15 shall coordinate all control and interlock wiring including connection to equipment and to source of supply with Division 16. Division 16 to verify with all other divisions.
- .7 Power wiring is defined as all single or three phase wiring carrying the full line current of the mechanical equipment, including all wiring of line voltage controls and isolation disconnects connected in line between the source and the mechanical equipment and including connection to the equipment.
- .8 Control and interlock wiring is defined as all mechanical equipment wiring other than power wiring outlined above.

- .9 Division 15 will provide detailed wiring diagrams for each motor for equipment under that division.
- .10 Division 16 unless specifically indicated otherwise, will provide all wiring for damper motor power and control from nearest panel except where the drawings indicate power outlets by Division 15. For these instances Division 16 will wire from the outlet to the damper motor.
- .11 Ascertain exact location of starters, motors and line voltage controls from Mechanical Drawings. If no starter location is indicated on the Electrical Drawings, obtain it from the Mechanical Drawings or from the Architect prior to closing of Tenders. This shall also apply to motors indicated on single line distribution diagrams but not the floor plans.

2.10 PAINTING

- .1 Unless otherwise specified, all surface mounted equipment such as panels, switchboards, transformers, etc. shall have factory prefinished exterior surfaces. All prefinished equipment surfaces shall be cleaned and any scratches shall be touched up with original paint on completion of project.
- .2 All equipment intended for recessing, such as flush panels and recessed electric heaters and equipment specified with finish suitable for painting shall have factory applied prime coat of paint. Final painting of prime painted equipment will be done under Painting section of this or general contractor's specification.
- .3 If in the Architect's opinion, touching up is not sufficient to provide a satisfactory appearance, the equipment shall be replaced and/or repainted to the Architect's approval.

2.11 IDENTIFICATION OF EQUIPMENT

- .1 All power, lighting, signal and telephone panels, disconnect switches, starters, contactors and time switches shall be identified with black plastic laminated (Lamacoid) nameplates with white engraving, secured to the equipment with screws, to indicate function, voltage and designation appearing on drawings.
- .2 Cover plates for recessed motor starters shall have engraved designation, to the satisfaction of the Architect, to differentiate them from light switches, e.g. "FAN".
- .3 All fusible units and/or breakers in power panels and switchboards shall be identified with black plastic laminated (Lamacoid) nameplates with white engraving secured with screws to indicate load served.
- .4 Surface mounted equipment shall have the nameplates mounted on exterior face of door or cover. Flush mounted equipment shall have the nameplates mounted at the top of the inside face of the door or cover.
- .5 Each panelboard shall have a typewritten legend to indicate area or equipment controlled by each branch circuit.
- .6 All feeders in pull boxes shall be tagged with load. Tags shall be T & B "E-Z Code" markers or equal.
- .7 Terminal strips in control panels shall be indexed and wires shall be colour coded.
- .8 Raceways and junction boxes of the various systems shall be identified by colour bars, dots or rings on the exterior of the raceway at 15 meters intervals and at termination points. The identification may be coloured adhesive tape or paint and shall be located 150" from the duct or conduit coupling. Sheathed cables shall be marked at 15meters intervals and at termination points.

- .9 All conductors shall be colour coded. All conductors No. 8 AWG and smaller shall have the colour impregnated into the insulation at the time of manufacture. In the case of conductors size No. 6 gauge and larger they may be colour coded with adhesive colour coding tape, but only black insulated conductors shall be employed in this case except for neutrals which shall be white whenever possible. Where colour coding tape is utilized, it must be applied for a minimum of 19mm at all terminations and junction boxes. Painting of conductors will not be accepted under any conditions. The colour coding shall also apply to all bussing in panels and bus ducts, in which the phasing shall be 'A', 'B', 'C', from left to right when facing the panel or vertical bus duct.
- .10 Conductor colour coding shall be as follows:
- Phase 'A' - Red
Phase 'B' - Black
Phase 'C' - Blue
Neutral - White
Ground - Green
Control - Orange
- Isolated Power Circuits - Orange and Brown
- Fire Alarm:
Stations - Red and Blue
Signals - Black and White
Detectors - Red and Blue
- .11 All equipment, including electrical motors, shall have a proper nameplate affixed thereto, showing the size, name of equipment, service, serial number, and all information usually provided which shall include voltage, frequency, phase, and horsepower of motors and the name and address of the manufacturer. All stamped, etched or engraved lettering on plates shall be perfectly legible to the satisfaction of the Engineers, Architect. Nameplates shall not be painted over, and where apparatus is to be insulated, nameplates shall be firmly attached with rigid insulation backup, of equal thickness of that of jacket.

2.12 TESTING

- .1 Make any tests required by the Architect, Engineers or owners during the progress of the work or at its completion. Provide all necessary labour and equipment for such tests. Such tests shall be carried out for the purposes of determining if the work as actually installed meets specified requirements.
- .2 Tests must last for duration specified, defects and faults developed shall be corrected and the test repeated to the satisfaction of the Owners, Architect, Engineers and the local authorities.

2.13 INSTRUCTIONS OF OWNER'S PERSONNEL

- .1 When the installation is completed and ready for acceptance, demonstrate to, and instruct, owners staff or representative in the operation of each piece of equipment and system. Provide required labour and equipment for the demonstrations and instructions.

2.14 SEQUENCE OF WORK

- .1 The work may have to be carried out in certain stages. Refer to Architectural Specifications for further details.

PART 3 - EXECUTION

3.1 CUTTING & PATCHING

- .1 Where construction has proceeded without appropriate provisions for the installation of sleeves, conduits, outlet boxes, etc., it shall be responsibility of this Division to do all necessary cutting and patching of the structure and/or finished surfaces to enable installation of such items.
- .2 Such cutting and patching shall be done by tradesmen skilled in that particular work and to the full approval of the Owners, at the expense of this Division.

3.2 SPACE FOR FUTURE EQUIPMENT

- .1 Where it is indicated that equipment is to be installed in future, leave such space clear and install the conduits, outlets, equipment and other work in such a way that future equipment installations and connections can be made. Consult with the representative of the Architect or Engineers whenever necessary for the purpose.

3.3 METALS

- .1 Provide all required miscellaneous metals.

3.4 ACCESS PANELS & DOORS

- .1 Provide access panels and doors wherever required for access to junction boxes for equipment.
- .2 Indicate all access panels and doors on construction drawings. Do not install any access panels or doors without prior approval of Consultant. Indicate location of all access panels and doors on Record Drawings.
- .3 Provide all panels, doors and frames to the appropriate Division for installation at the cost of this Division.
- .4 Minimum sizes shall be 150mm x 150mm (6"x6") for hand access, 600mm x 450mm (24"x18") for person access.
- .5 Provide access doors with fire rating equal to the surfaces in which installed.
- .6 Provide panels in glazed tile walls of 2.5mm (12 gauge) 304 stainless steel #4 finish, with recessed frames secured with counter-sunk flush-head tamper proof screws.
- .7 Provide panels in plaster surfaces with recessed doors with welded metal lath ready to accept plaster and with a plaster grommet for door key access.
- .8 Provide other access doors of 2.5mm (12 gauge), flush with concealed hinges, anchor strap and lock, all factory prime coated and tamper proof screws.
- .9 Supply details of doors prior to installation. Submit shop drawings of size, type and location.
 - .1 Mark all lay-in tiles that are used for access in a manner approved by the Consultant.

PART 1 - GENERAL

1.1 Work Included

- .1 Drawings do not show all conduits. Those shown are in diagrammatic form only.
- .2 Provide the necessary embedded and surface-mounted conduit required to make systems safe, complete and to size required.

PART 2 - PRODUCTS

2.1 Conduits

- .1 Rigid, schedule 40, galvanised steel threaded conduit: size as indicated.
- .2 Electrical metallic tubing (EMT): with couplings, size as indicated.
- .3 Rigid PVC conduit: size as indicated.
- .4 Flexible metal conduit and liquid-tight flexible metal conduit: size as indicated.
- .5 A conduit by Alcan for surface mounting exposed to weather conditions, complete with all threaded fabricated accessories.
- .6 Flexible non-metallic corrugated tubing (ENT) where encased in concrete, masonry or completely concealed in metal stud drywall partitions.

2.2 Conduit Fastenings

- .1 One hole steel straps to secure surface conduits 50 mm (2") and smaller. Two hole steel straps for conduits larger than 50 mm (2").
- .2 Beam clamps to secure conduits to exposed steel work.
- .3 Channel type Unistrut supports for two or more conduits at 1500 mm (5') o.c.
- .4 13 mm (1/2") diameter or larger threaded rods to support suspended channels.

2.3 Conduit Fittings

- .1 Fittings for raceways: to CSA C22.2.
- .2 Fittings manufactured for use with conduit specified.
- .3 Factory 'ells' where 90° bends are required for 25 mm (1") and larger conduits.
- .4 Rain tight connectors and couplings for EMT. For EMT conduits sizes 65mm (2-1/2") and over, use set screw connectors and couplings.
- .5 Equipment top entry in sprinkler areas shall have 'O' sealing rings.

2.4 Expansion Fittings

- .1 Watertight expansion fittings with integral bonding jumper suitable for linear expansion and 19 mm (3/4") deflection in all directions to suit expansion joints. Crouse-Hinds 'XJ' type for steel. IPEX 'O' ring type 'EJ' for rigid PVC.

- .2 Weather proof expansion fittings with internal bonding jumper assembly suitable for 100 mm (4") linear expansion.

2.5 **Fish Cord**

- .1 Polypropylene to suit weight of cable being pulled.

PART 3 - EXECUTION

3.1 **Installation**

- .1 Install conduits to conserve headroom in exposed locations and cause minimum interference in space through which they pass.
- .2 Conceal all conduits except in unfinished areas or unless otherwise permitted.
- .3 Use expansion fittings when conduits cross expansion joints.
- .4 Use rigid, threaded, galvanised steel threaded conduit from floor slabs to 1500mm above floor where run exposed.
- .5 Use electrical metallic tubing (EMT) for interior except in poured concrete.
- .6 Conduits installed exposed in wet locations shall be rigid galvanised steel with threaded fittings.
- .7 Use rigid PVC conduit underground. No PVC conduits shall be used run exposed in the interior of the building.
- .8 Use flexible metal conduit by type for connection to motors in dry areas, connection to surface or recessed fluorescent fixtures and work in movable metal partitions.
- .9 Use liquid-tight flexible metal conduit for connection to motors in damp, wet or corrosive locations equal to "Onaconda Blue", complete with separate ground wire.
- .10 Bend conduit cold. Replace conduit if kink or flattened more than 1/10th of its original diameter.
- .11 Install polypropylene fish cord in all empty conduits. Fish wires shall be minimum #8 nylon cord.
- .12 Run 2 - 25 mm (1") spare conduits up to accessible ceiling space from each flush panel. Terminate these conduits in 152 x 152 x 102 mm (6" x 6" x 4") junction boxes in ceiling space or, in case of an exposed concrete slab, terminate each conduit in a flush concrete type box.
- .13 Where conduits become blocked, remove and replace blocked section; abandon if necessary and run new. If fire alarm or emergency circuit run on surface, maintain the required fire rating.
- .14 Install proper conduit caps during installation to avoid water and construction debris from entering conduits.
- .15 Use flexible non-metallic (ENT) tubing in poured concrete. Runs must be continuous without couplings from box to box. ENT conduits shall only be used in the garage level shall be within poured concrete walls or floor slabs. Exposed conduits shall be EMT.

- .16 Dry conduits out before installing wire.

3.2 **Surface Conduits**

- .1 Run parallel or perpendicular to building lines.
- .2 Locate conduits 150mm clearance of heat producing equipment.
- .3 Run conduits in flanged portion of structural steel.
- .4 Group conduits wherever possible on recessed channels. Surface or suspended channels may be used if unavoidable.
- .5 Do not locate conduits less than 75 mm (3") parallel to hot water lines with a minimum of 25 mm (1") at crossovers.

3.3 **Concealed Conduits**

- .1 Do not install horizontal runs in masonry walls.
- .2 Do not install conduits in concrete toppings.

3.4 **Conduits in Poured Concrete**

- .1 Install conduits to CSA requirements for conduits set in concrete.
- .2 Locate to suit reinforcing steel. Install in centre one-third of slab.
- .3 Protect conduits from damage where they stub out of concrete.
- .4 Install sleeves where conduits pass through slab or wall.
- .5 Where conduits pass through waterproof membrane, provide oversized sleeve to accommodate special conduit fitting, equal to PEM #6372, before membrane is installed. Use cold mastic between sleeve and conduit.
- .6 Encase conduits completely in concrete so that conduit is enclosed evenly on the top as on the bottom of itself.

3.5 **Conduits in Poured Slabs on Grade**

- .1 Run conduits 25 mm (1") and larger below slab and encased in 75 mm (3") concrete envelope. Provide 50 mm (2") of sand over concrete envelope below floor slab.

3.6 **Conduits Underground**

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

PART 1 - GENERAL

1.1 **Work Included**

- .1 Provide wireways and auxiliary gutters required to suit installation.

PART 2 - PRODUCTS

2.1 **Wireways**

- .1 Wireways to CSA C22.2 No. 62.
- .2 Aluminium with hinged, bolted cover to give uninterrupted access and suitable for padlock.
- .3 Cross-section dimensions: sized to suit requirements.
- .4 Finish: baked grey enamel.
- .5 Elbows, tees, couplings and hanger fittings manufactured as accessories to wireway supplied.
- .6 Weatherproof where indicated on drawings.

PART 3 - EXECUTION

3.1 **Installation**

- .1 Install wireways and auxiliary gutters as indicated.
- .2 Keep number of elbows, offsets, connections to minimum.
- .3 Install supports, elbows, tees, connectors, fittings.
- .4 Install gutter to full length of equipment.
- .5 Seal all conduit entries in weatherproof wireways.
- .6 Provide lamacoid identification labels.

PART 1 - GENERAL

1.1 Work Included

- .1 Provide building wires to suit requirements of individual systems as specified herein.

1.2 Standards

- .1 Corflex (aluminium sheathed cables) shall be in accordance with CSA Standard C22.2 No.123-M1985.
- .2 All cables installed in areas requiring fire rating shall conform to test FT-6 and or FT-4 as required by the Ontario Building Code.

PART 2 - PRODUCTS

2.1 Building Wires

- .1 Conductors (wires in conduit): Annealed commercial grade, 98 percent conductivity, stranded copper or nual aluminium as shown on the drawings.
- .2 Insulation: R90. Thermosetting polyethylene insulation rated at a minimum of 600V.
- .3 Colour Coding:
 - .1 Two conductor, 1 phase: 1 black, 1 white.
 - .2 Three conductor, 1 phase: 1 black, 1 red, 1 white.
 - .3 Three conductor, 3 phase: 1 black, 1 red, 1 blue.
 - .4 Four conductor, 3 phase: 1 black, 1 red, 1 blue, 1 white.
 - .5 Ground Wires: Code size Green.

2.2 Aluminium Sheath Cables

- .1 Conductors shall be of sizes as indicated. Each cable shall have a grounding conductor. #14 and larger - stranded. Aluminium (NUAL) may be used in lieu of copper for rated current 100A and above and shall be sized according to Ontario Electrical Safety Code.
- .2 Insulation: Chemically cross-linked thermosetting polyethylene insulation rated at a minimum of 600V, type R90.
- .3 Inner jacket: Polyvinyl chloride inner jacket
- .4 Armour: Corrugated continuous aluminium armour.
- .5 Overall jacket: Thermoplastic polyvinyl chloride LFS/LGE overall jacket for fire protection and low acid gas evolution, meeting the requirements of the Vertical Tray Fire Test to CSA Standard C22.2 No. 0.3 with a maximum flow travel of 1.2M (4'). (Conform to FT4).
- .6 Fastenings:
 - .1 One hole non-magnetic iron straps to secure surface mounted cables.
 - .2 12 gauge aluminium channel type supports for two or more cables at 1.5M (5') o.c.
 - .3 6mm (1/4") diameter threaded rods to support the suspended channels.

.7 Connectors:

.1 Watertight, T & B series 10464 and 10470.

2.3 **Armoured Cables (Branch Circuits)**

.1 Type: AC90-XLPE (BX) - Multi-conductor.

.2 Conductor Material: Annealed solid commercial grade 98 percent conductivity tinned copper.

.3 Size: #12 to #10 only cross-linked polyethylene with R90, 600 volt rating.

.4 Colour Coding:

.1 Two conductor, 1 phase: 1 black, 1 white.

.2 Three conductor, 1 phase: 1 black, 1 red, 1 white.

.5 Grounding: Un-insulated, solid copper.

.6 Separator: Impregnated paper.

2.4 **General**

.1 Minimum wire size shall be #12 AWG copper stranded to all devices and equipment, #14 copper stranded for controls unless otherwise stated. Home runs shall not exceed 25 m for circuits protected by a 15A over-current device.

.2 Maximum voltage drop between the furthest outlet of a fully loaded circuit and the panel to which it is connected shall not exceed 2%.

.3 Provide pull boxes at maximum in runs exceeding 22 m (70').

PART 3 - EXECUTION

3.1 **Installation**

.1 General:

.1 Install wiring as follows:

.1 In conduit systems in accordance with Section 16111.

.2 In wireways in accordance with Section 16112.

.2 Do not use any neutral conductor as a grounding conductor.

.3 Code size green ground conductor in all raceways.

.4 Do not splice any wiring in any raceway. Make splices only at junction boxes.

.5 Provide sufficient slack of cables at the connection points to permit proper connections to be made to equipment.

.6 Do not install conductors in any raceway until the raceway is complete and cleared of all obstructions.

-
- .2 Armoured Cables (BX) - (Branch Circuits)
 - .1 These cables shall be installed concealed and be used only for the following purposes:
 - .1 Final connection from a ceiling outlet box to a lighting fixture.
 - .2 Wiring in drywall ceiling and partitions.
 - .2 Use only approved connectors and anti-short sleeves at all dressed ends.
 - .3 Building Wire
 - .1 Wiring of the following circuits and systems shall be installed in separate conduit system:
 - .1 Normal power to lighting fixtures.
 - .2 Normal power to receptacle outlets at 120 volt.
 - .3 Mechanical equipment and system wiring.
 - .4 H.V.A.C. systems wiring.
 - .5 Other auxiliary systems.
 - .6 Cable T.V.
 - .7 Telephone and communications.
 - .8 Security Systems.
 - .9 Emergency Lighting.
 - .10 Fire Alarm.
 - .2 Provide pigtails at all outlets for fixtures and wiring devices. All neutrals and branch circuits shall be connected in each outlet box to avoid a break in the neutral or the circuit wire when fixture or wiring device is disconnected.
 - .3 Current carrying capacity of the feeders, sub-feeders and branch circuit conductors shall be equal to or better than shown on the drawings.
 - .4 All branch circuit connections shall be made with Ideal "Wing Nuts" applied with a proper tool, or approved equal.
 - .5 All control conductors shall be colour coded and records of colour coding submitted with the record drawings.
 - .6 All power and control cables **shall be identified** at each piece of equipment with Electrovert Strip wiring clips having suitable identification markings.
 - .7 Number of wires indicated for power, motor and motor control, and all other auxiliary systems is intended to show the general scheme only. The required number and type of wires shall be installed in accordance with the manufacturer's diagrams and requirements, and with the requirements of the installation.
 - .8 Run a green insulated ground wire in all power and branch circuit conduits for 120, 208 and 600 volt circuits. At each junction, pull and outlet box make a 360° loop of the stripped uncut conductor under the ground screws.

PART 4 - FIRE ALARM WIRING

- 4.1 All fire alarm wiring shall be of copper, and installed as a minimum, in accordance with section 32 of the Ontario Electrical Safety Code, current edition, and
- 4.2 All wiring shall be FT4 or FT6 rated, and
- 4.3 All signal appliance wiring shall be No. 18 AWG minimum, and
- 4.4 All fire alarm wiring shall be installed in a two hour fire rated enclosure.
- 4.5 In lieu of the two hour fire rated enclosure, two hour fire rated cables are an acceptable alternates, such as "Lifeline", "Vitalink" or M.I. cables.

PART 1 – GENERAL

1.1 Work Included

- .1 Wiring to be Mineral Insulated (M.I.) “Lifeline” or “Vitalink” cable with Two Hour Fire Rating as listed by Underwriters Laboratories of Canada (ULC).
- .2 All wiring shall be in accordance with the latest edition of the Ontario Electrical Safety Code and/or the authority having jurisdiction and the Manufacturer’s Recommendations.

1.2 Standards

- .1 Basic electrical requirements 16010.
- .2 Basic materials and methods 16050.
- .3 Wires and cables 16120.

PART 2 - PRODUCTS

2.1 Storage

- .1 Cables to be shipped from manufacturing facility with ends temporarily sealed.
 - .1 When cables are cut in the field, ends are to be sealed by means of standard sealing compound and PVC tape, or equivalents, acceptable to the Engineer.
- .2 Cables should be stored under clean and dry conditions.

2.2 Handling

- .1 Cable to be uncoiled by rolling, or by means of a supply reel (available from the manufacturer) rather than pulling from the periphery or the centre of the coil. This will greatly ease the handling and prevent possible snaring and kinking.
- .2 Precautions to be taken against brutal blows with sharp instruments and pulling over sharp objects.

PART 3 - EXECUTION

3.1 Installation - Cable

- .1 Cable can be installed either exposed, in tray, or embedded.
- .2 The specifications shall govern the method of installation for any particular application, but, where none is given, then each of the methods shall comply with the following.
 - .1 Exposed or Surface Installations:
Cable or cables can be clipped directly to walls, beams, purlins or ceilings, using the required clips or straps available from the manufacturer. For the rated circuits the spacing of cable supports shall not exceed 1000 mm.
 - .1 Exposed runs of cables shall be installed parallel to building lines and present a neat appearance.

- .2. Embedded Installations:
Cables embedded in concrete shall be protected by means acceptable to the engineer, against puncture damage from the medium itself or the pouring equipment and have an overall protection of a PVC jacket.
 - .1 Where cable emerges from a slab, protection against sheer damage shall be provided by means of a short PVC conduit stub, metal plate or angle, at the point of egress.
- .3 Bending - Hickeys are available from the manufacturer and shall be used for all bends, to achieve a workmanlike result.
 - .1 Recommended minimum bend radius is 6 times (6X) the cable diameter. Closer bends are possible with approval of the engineer.
- .4 Single conductor cables forming part of a circuit shall be run close together with sheaths touching, throughout their length.
 - .1 Single conductor cables in parallel shall be "phased out" in groups and the groups spaced at least two cable diameters apart.
 - .1 Parallel cables shall be the same length.

3.2 Terminating of Cable

- .1 Cables shall be terminated with glands and seals, available from the manufacturer, approved for the application and installed according to the manufacturer's recommendations.
- .2 Stripping tools, pot wrenches, crimping and compressing tools, available from the manufacturer, and designed for the purpose, shall be used to prepare the cable and install the glands and seal assemblies.
- .3 Upon completion of the terminations, the insulation resistance of the cable shall be checked with a 500 volt insulation tester and a resistance value achieved which is acceptable to the Engineer.

3.3 Connections to Ferrous Metal Enclosures

- .1 When using single conductor cables carrying currents in excess of 200 amperes, induction heating by hysteresis will occur if precautions are not taken. To prevent this effect, one of the following methods shall be used:
 - .1 In dry locations, a slot about 0.8 mm wide can be cut with a hacksaw between the knockouts in the box.
 - .2 For damp locations, or where the enclosure would be unduly weakened by "slotting", a brass plate 6 mm minimum thickness shall be substituted for the steel of the box, by cutting out of the box section containing the knockouts or entry holes, and fixing the brass plate securely to the box by means of a minimum of four bolts.

3.4 Workmanship

- .1 Following the recommendations of the manufacturer will consistently produce satisfactory installations. The installer shall avail himself of the services of the Manufacturer's Field Technician who will offer instruction on proper installation techniques.

PART 1 - GENERAL

1.1 Work Included

- .1 Provide the necessary outlet boxes, pull and junction boxes.
- .2 Drawings do not show all outlet boxes, pull and junction boxes required. Those shown are the minimum required to convey intent.
- .3 Indicate all boxes on 'as-built' drawings.

1.2 Standards

- .1 Outlet boxes, conduit boxes and fittings are based on CSA C22.2 No. 18-M1987.
- .2 Size boxes in accordance with CSA C22.1-1994, Section 12-303B and tablets 22 & 23.

PART 2 - PRODUCTS

2.1 Outlet and Conduit Boxes - General

- .1 102 mm (4") square or larger outlet boxes as required for special devices, complete with single or two gang plaster ring to suit application.
- .2 Gang boxes where wiring devices are grouped.
- .3 Blank cover plates for boxes without wiring devices.
- .4 120V outlet MBD boxes for 120V devices.
- .5 Combination boxes with barriers where outlets for more than one system are grouped.
- .6 PVC moulded junction boxes for PVC conduit in concrete or where exposed to corrosion.

2.2 Sheet Steel Outlet Boxes

- .1 Electro-galvanised steel, single and multi-gang flush device boxes for flush installation, minimum size 76 X 50 X 38 mm (3" X 2" X 1-1/4"), 102 mm (4") square outlet boxes when more than one conduit enters one side, with extensions and plaster rings as required.
- .2 102 mm (4") square or octagonal outlet boxes for lighting fixture outlets.
- .3 102 mm (4") square outlet boxes with extension and plaster rings for flush mounting devices in finished plaster or tile walls.

2.3 Masonry Boxes

- .1 Electro-galvanised steel masonry single and multi-gang MBD boxes for devices flush mounted in exposed block walls.

2.4 Concrete Boxes

- .1 Electro-galvanised sheet steel concrete type boxes for flush mount in concrete with matching extension and plaster rings as required.

2.5 **Conduit Boxes**

- .1 Cast FS or FD ferroalloy boxes with factory-threaded hubs and mounting feet for all outlet boxes connected to surface mounted conduit.

2.6 **PVC Boxes**

- .1 Use IPEX type F and FSS series boxes in special corrosive areas, such as planters and in poured concrete.

2.7 **Fittings General**

- .1 Bushing and connectors with nylon insulated throats.
- .2 Conduit outlet boxes for conduit up to 32 mm (1-1/4") and pull boxes for larger conduits.
- .3 Double lock nuts and insulated bushings on sheet metal boxes.

2.8 **Outlet Box Finish**

- .1 All outlet boxes i.e. receptacle, toggle light switch controls shall be Decora Designer Series throughout. Colour shall be Architect.
- .2 Outlet boxes i.e. receptacle, toggle, light switch controls shall be Decora Designer Series mirror finish where such are located in mirror finished areas. Refer to Interior Designer and their drawings for locations.
- .3 All exhaust fan toggle controls shall be Decora Designer Series paddle type c/w pilot light and cover. Typical throughout. Colour shall be by Architect.

PART 3 - EXECUTION

3.1 **Installation**

- .1 Support boxes independently of connecting conduits.
- .2 For flush installations, mount outlets flush with finished wall using plaster rings to permit wall finish to come within 12 mm (1/2") of opening.

PART 1 - GENERAL

1.1 Work Included

- .1 Drawings do not show all splitters, junction and pull boxes and cabinets.
- .2 Provide the necessary splitters, junction, pull boxes and terminal cabinets required to make systems complete and operational.

1.2 Standards

- .1 Splitters are based on CSA C22.2 No. 76-M1981. Junction and pull boxes are based on CSA C22.2 No. 40-M1989.

PART 2 - PRODUCTS

2.1 Splitters

- .1 Sheet metal enclosures, welded corners and formed hinged cover suitable for locking in closed position.
- .2 Connection bars to match required size and number of incoming and outgoing conductors.
- .3 At least three (3) spare terminals on each set of lugs in splitters less than 400A.

2.2 Junction & Pull Boxes

- .1 Welded steel construction with screw-on flat covers for surface mounting. Minimum size: 150 mm X 150 mm (6" X 6").
- .2 Covers with 25 mm (1") minimum extension all around for flush mounted pull and junction boxes.
- .3 PVC 'Scepter' type junction and pull boxes shall be PVC moulded type equal to Scepter JB series.

2.3 Cabinets

- .1 Type 'E': sheet steel, hinged door and return flange overlapping sides, handle and catch, for surface mounting.
- .2 Type 'T': sheet steel with hinged door, latch, lock, two (2) keys, containing 19 mm (3/4") fire resistant fir plywood backboard for surface or flush mounting.

PART 3 - EXECUTION

3.1 Splitter Installation

- .1 Install splitters vertically or horizontally as indicated and mount plumb, true and square to the building lines.
- .2 Extend splitters along the full length of the equipment arrangement.

3.2 **Junction Boxes Pull Boxes & Cabinet Installation**

- .1 Install pull boxes in inconspicuous but accessible locations. Provide access panels where required.
- .2 Mount cabinets with top not higher than 2 m (6') above finished floor.
- .3 Install terminal block in Type 'T' cabinets.
- .4 Only main junction and pull boxes are indicated. Provide pull boxes so as not to exceed 30 m (100') of conduit run between pull boxes.

3.3 **Installation**

- .1 Install legible lamacoid identification labels indicating system name, voltage and phase.

PART 1 - GENERAL

1.1 Work Included

- .1 Provide wire and box connectors for cable types used.

PART 2 - PRODUCTS

2.1 Materials

- .1 Cable Connectors
 - .1 For armoured cables, T & B series watertight.
 - .2 For armoured BX cables, T & B 'Tite-Bite' steel with nylon insulated throat.
 - .3 Building Wire Connectors
 - .1 For wire sizes #12 to #6 AWG rated for 105° C or less:
 - .2 Ideal 'Wing Nut'.
 - .3 For wire sizes #4 AWG and larger:
 - .1 At studs and bus bars - Burndy QQA (CU/AL);
 - .4 Lugs, terminals, screws used for termination of wiring shall be suitable for either copper or aluminium (NUAL) conductors.
 - .5 Insulation Tapes (Up to 750 Volts)
 - .1 Exposed splices for all circuitry in wet and dry locations for wire rated 105° C (220° F) and less - insulate with Scotch Brand No. 99 vinyl tape.
 - .6 Clamps or connectors for armoured cable, mineral insulated cable, flexible conduit, non-metallic sheathed cable as required.

PART 3 - EXECUTION

3.1 Installation

- .1 Remove insulation carefully from ends of conductors and:
 - .1 Install mechanical pressure type connectors and tighten screws with appropriate compression tool recommended by manufacturer. Installation shall meet secureness tests in accordance with CSA C22.2 No. 65-1956-M1988.
 - .2 Install fixture type connectors and tighten. Replace insulating cap.

PART 1 - GENERAL

1.1 Related Work

- .1 Conduits: Section 16111.
- .2 Wires and Cables: Section 16120
- .3 Outlet, Conduit Boxes and Fittings: Section 16130

PART 3 - EXECUTION

3.1 Installation

- .1 120/208V and 600V power distribution system:
 - .1 In all interior areas, wires in EMT conduits for overhead feeders and branch wiring with the following exceptions:
 - .1 Final drops from junction boxes to equipment may be made with type AC90-XLPE cable or wire in conduit.
 - .2 Type AC90-XLPE cable may also be used only for branch wiring concealed within drywall partitions or ceilings.
 - .2 Motor and control wiring - wire in conduit. This requirement applies for Division 15 and 16.
 - .3 Except in utility spaces, all wiring shall be concealed. No exposed AC90-XLPE cables shall be permitted.

PART 1 - GENERAL

1.1 Work Included

- .1 Provide all labour, equipment, materials and services for fastening and supporting electrical equipment.

PART 2 - PRODUCTS

2.1 Support Channels

- .1 U shape, single channel aluminium to suit load to be carried, surface-mounted, suspended, set in poured concrete walls and ceilings as indicated or required.

2.2 Fittings and Accessories

- .1 Support equipment, conduit or cables using clips, spring loaded bolts, cable clamps designed as accessories to basic channel members.

PART 3 - EXECUTION

3.1 Installation

- .1 Secure equipment to solid masonry, tile and plaster surfaces with lead anchors.
- .2 Secure equipment to poured concrete with self-drilling expandable inserts.
- .3 Secure equipment to hollow masonry walls or suspended ceilings with toggle bolts.
- .4 Secure surface-mounted equipment with twist clip fasteners to inverted T-bar ceilings. Ensure that T-bars are adequately supported to carry weight of equipment specified before installation.
- .5 Provide Consultant with weight of equipment attached to T-bars.
- .6 Fasten exposed conduit or cables to building construction or support system using straps or channels.
 - .1 One-hole steel straps to secure surface conduits 50 mm (2") and smaller.
 - .2 Two-hole steel straps for conduits larger than 50 mm (2").
 - .3 Beam clamps to secure conduit to exposed steel work.
 - .4 Aluminium cable clamps for Corflex cables.
- .7 Suspended support systems:
 - .1 Support individual cable or conduits runs with 12 mm (1/2") diameter threaded rods and spring clips.
 - .2 Support two (2) or more cables or conduits on channels supported by 12 mm (1/2") diameter threaded rod hangers where direct fastening to building construction is impractical.
 - .3 Support suspended luminaries using two (2) or more lengths of Weldless 'Single Jack', bright zinc plated steel, Canadian Standard #10 gauge, 13 links per foot.

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- .8 For surface mounting of two or more conduits, use channels at 900 mm (3') o.c. spacing.
 - .9 Provide metal brackets, frames, hangers, clamps and related types of support structures where indicated or as required to support conduit and cable runs.
 - .10 Ensure adequate supports for raceways and cables dropped vertically to equipment where there is no wall support.
 - .11 Do not use wire lashing or perforated strap to support or secure raceways or cables.
 - .12 Do not use supports or equipment installed for other trades for conduit or cable support except with permission of other trades and approval of Consultant.

PART 1 - GENERAL

1.1 General

- .1 Furnish and install a complete ULC-listed system of heating cables, components, and controls to prevent pipelines from freezing.

PART 2 - PRODUCTS

- 2.1 The self-regulating heating cable shall consist of two(2) 16 AWG tinned-copper bus wires embedded in parallel in a self-regulating polymer core that varies its power output to respond to temperature all along its length, allowing the heating cable to be cut to length in the field. The heating cable shall be covered by a radiation cross linked, modified polyolefin dielectric jacket. To provide a ground path and to enhance the heating cable's ruggedness, the heating cable shall have a braid of tinned-copper and an outer jacket of modified polyolefin (-CR).

Optional: For installation on plastic piping, the heating cable shall be applied using aluminium tape (AT 180).

- 2.2 In order to conserve energy and to prevent overheating, the heating cable shall have a self-regulating factor of at least 90 percent. The self-regulation factor is defined as the percentage reduction, without thermostatic control, of the heating cable output going from 40°F pipe temperature operation to 150°F pipe temperature operation.
- 2.3 The heating cable shall operate on line voltages of 120, volts without the use of transformers.
- 2.4 The heating cable shall be sized according to the table below. The required heating cable output rating is in watts per foot at 50°F. (Heating cable selection based on 1" fibreglass insulation on metal piping.)

Pipe Size	Minimum Ambient -10°F	Temperatures -20°F
3 in or less	5 watts	5 watts
4 in	5 watts	8 watts
6 in	8 watts	8 watts
8 in	2 strips-5 watts	2 strips-8 watts
12 in to 14 in	2 strips-8 watts	2 strips-8 watts

- 2.5 The heating cable shall be XL-Trace as manufactured by Raychem Corporation or equal by Chromalox or Pyrotenax.

- 2.6 Power connection, end seal, splice, and tee kit components shall be applied in the field.

2.7 System Control

- .1 Thermostatic Control-Ambient Sensing

The system shall be controlled by an ambient sensing thermostat (choose: AMC-1A or AMC-F5) set at 40°F either directly or through an appropriate contactor.

PART 3 - EXECUTION

3.1 Installation

- .1 Apply the heating cable linearly on the pipe after piping has been successfully pressure tested. Secure the heating cable to piping with cable ties or fibreglass tape.
- .2 Apply "Electric Traced" signs to the outside of the thermal insulation.

3.2 Tests

After installation and before and after installing the thermal insulation, subject heating cable to testing using a 2500 Vdc Megger. Minimum insulation resistance shall be 20 to 1000 megohms regardless of length.

PART 4 - RAMP SNOW MELTING (IF APPLICABLE)

- 4.1 Division 16 shall provide and install a complete operating snow melting system as indicated on the drawings and as herein specified.
- 4.2 The system shall be automatically controlled by a snow controller, type ADS-3, snow sensor CIT-1, and high and low protection thermostats.
- 4.3 Cable installation shall be in accordance with manufacturer's specifications.
- 4.4 Cables shall not cross expansion joints.
- 4.5 Insulation resistance tests shall be carried out:
 - .1 Prior to cable installation.
 - .2 After cable installation, but prior to application of covering.
 - .3 After final covering application.
- 4.6 The cable manufacturer shall inspect the cable installation and approve it prior to the application of the covering over the cables.

The manufacturer shall submit an inspection report to the consulting engineer verifying that the installation is in accordance with the manufacturers' specifications and guidelines.

The cost of this inspection and report is part of Division 16 scope of work.

PART 1 - GENERAL

1.1 Work Included

- .1 Provide fuses as specified.

1.2 Shop Drawings & Product Data

- .1 Submit shop drawings and product data in accordance with Section 16010.
- .2 Submit average fuse melting and I^2T clearing time-current characteristics for each fuse type and size above 200A. Submit peak let through current for all fuses above 200A.
- .3 Provide three spare fuses of each type and size installed.

PART 2 - PRODUCTS

2.1 Fuses - General

- .1 All fuses provided shall be of the same manufacturer.
- .2 Fuses greater than 600 amps shall be 'BUSMAN' H.R.C., Form-1, Class 'L', Hi-cap, time delay.
- .3 Fuses 600 amperes or less shall be 'BUSMAN', H.R.C., Form-1, 'Low Peak', time delay, Class 'J' or equal.
- .4 This division shall clearly mark on the inside cover of each fusible unit, the amperage rating, and catalogue number of replacement fuses to be used.
- .5 Fuses shall be sized in accordance with load criteria and manufacturers' recommendations. Fuse supplier shall provide a fuse co-ordination study for review by Engineers.
- .6 Provide three spare fuses of every size and type used in a lockable floor mounted cabinet stored in the main Electrical Room.
- .7 Fuses manufactured by FERRAZ SHAWMUT shall be considered as equal.

PART 3 - EXECUTION

3.1 Delivery & Storage

- .1 Ship fuses in original containers.
- .2 Do not ship installed fuses in switchboard.
- .3 Store fuses in original containers in storage cabinet.

3.2 Installation

- .1 Install fuses in mounting devices immediately before energising circuit.
- .2 Ensure correct size, and type of fuses fitted to assigned electrical circuit.
- .3 Follow co-ordination curves to ensure correct fuse is placed in proper device.

- .4 Provide a lockable enclosure in electrical room 914 mm x 609.6 mm x 304.8 mm complete with one (1) extra set of fuses as installed in each fusible switch, disconnect throughout building.

3.3 **Manufacture**

- .1 Fuses manufactured by Ferraz Shawmut, Bussman, English Electric and Schneider Electric are considered equal.

PART 1 - GENERAL

1.1 WORKED INCLUDED

- .1 Provide complete systems, including all necessary labour, services, products, materials and equipment as shown on the Drawings, listed in the Schedules and as specified herein.

1.2 REFERENCE STANDARDS

- .1 Provide all work in accordance with all applicable codes and to the requirements of all local authorities having jurisdiction, including all applicable by-laws.

The equipment shall be built to the following standards:

CSA C22.2 No. 193-M1989 (Interrupter Switch)
CSA 22.2 No. 31, M1989 (Switchgear Assemblies)
EEMAC G8-2, 1972 (Switchgear Assemblies)
ANSI C37.20.3 1987 (Switchgear Assemblies)
Toronto Hydro Customer Owned 13.8 KV Substation requirements" (Latest issue)

The manufacturer shall provide, upon request, certified test data for any assembly or component to substantiate the following ratings.

PART 2 - PRODUCTS

2.1 CUTTING & PATCHING

- .1 Provide all cutting and patching of existing work or any made necessary by not informing other Trades of the need for any cutting and patching.
- .2 Patch and seal all floor and wall openings with fire resistant insulation and mastic.

2.2 SWITCHGEAR RATINGS

The assembly rating shall be as follows; -

Voltage - Maximum	15 kv
- Nominal	13.8 kv
B.I.L.	95 kv
Short Circuit Ratings	25,000 amperes (sym)
.....	600 mva
Fault Closing.....	40,000 amperes (asym)
Main Bus (copper or aluminum)	600 amperes

2.3 ENCLOSURES

The enclosure shall be Indoor weatherproof construction with front access only. The construction shall be welded 11-gauge flat rolled steel complete with a four-inch steel channel welded along the bottom. The finish shall consist of ANSI #61 Gray for indoor. A mimic bus and identification nameplate may also be included.

2.4 INTERRUPTER SWITCHES

Interrupter switch rating shall be as follows; -

Voltage - Maximum	17 kv
- Nominal.....	13.8 kv
B.I.L.	95 kv
Amperes continuous and interrupting.....	600 amperes
Short time (3 seconds)	25,000 amperes (sym)
Fault Closing (two time duty cycle)	40,000 amperes (asym)

The interrupter switches shall be factory aligned and tested on a frame before being installed in the switchgear. Interrupter units shall be fully enclosed and not rely on separate blades. The interrupter switches shall be the S&C type Alduti-Rupter.

2.5 POWER FUSE

The fuses shall be power fuse assemblies. A fuse assembly shall consist of a renewable fuse unit complete with exhaust filter and blown fuse indicator. The fuse units shall be full range, non-aging and non-damageable. The time current characteristics shall be NEMA "E" type. A standard and slow speed shall be available for each rating up to 400E amperes. Each fuse shall contain a silver arcing rod surrounded by epoxy cemented boric acid.

The fuse units shall be able to withstand voltage upon interrupting, thereby not requiring trip-pin operation of the switch. The fuses shall not have an MBC (minimum breaking current) nor shall they limit current such that over-voltages occur upon interruption. The fuses shall be constructed with a hinge on one end and a disconnecting latch on the other. It must be possible to remove the holder from the bay with only a grappeler equipped hook stick. Fuses shall be the S&C type SM-40.

2.6 VOLTAGE INDICATING DEVICES

Voltage sensing devices will be installed on all cable termination points, including at the incoming cable termination points by THEC and the outgoing feeders. Voltage indicators shall be visible thru a viewing window in front of the termination point. Capacitive coupled voltage indicating devices shall be installed on the load side of the fuses, visible thru a viewing window. These voltage indicating devices shall flash when voltage is present and be clearly visible from in front of the gear without opening any doors or panels.

2.7 INSULATORS AND ISOLATING BUSHINGS

The stand-off insulators shall be skirted and have a minimum of 26 inches of creepage distance to maintain the 125 kv BIL. Where required each bay shall be isolated from adjacent bays by S&C Electric Cypoxy through bushings. Insulators and isolating bushings shall be S&C Cypoxy.

2.8 Description

The number of bays shall be 3, comprising of 2 unfused load break switches and 1 fused load break switch.

PART 1 - GENERAL

1.1 WORKED INCLUDED

- .1 Provide complete systems, including all necessary labour, services, products, materials and equipment as shown on the Drawings, listed in the Schedules and as specified herein.

1.2 REFERENCE STANDARDS

- .1 Provide all work in accordance with all applicable codes and to the requirements of all local authorities having jurisdiction, including all applicable by-laws.

The equipment shall be built to the following standards:

CSA C22.2 No. 47
CSA C9
ANSI/IEEE C57.12.01
ANSI/IEEE C57.12.91
C802.2 (If Applicable)
Other relevant VL, CSA and IEEE Standard

The manufacturer shall provide, upon request, certified test data for any assembly or component to substantiate the ratings specified.

PART 2 - PRODUCTS

2.1 CUTTING & PATCHING

- .1 Provide all cutting and patching of existing work or any made necessary by not informing other Trades of the need for any cutting and patching.
- .2 Patch and seal all floor and wall openings with fire resistant insulation and mastic.

2.2 CONSTRUCTION

- .1 Rating – 1200 KVA, ANN with provision for fan cooling (ANF).
- .2 Voltage
 - Primary: Rated Voltage 15 KV
Operating Voltage 13.8KV
BIL Rating 95 KV
Delta
 - Secondary: Rated Voltage: 600/347 volt
Wye grounded with a 30° angular displacement (lagging) with respect to the primary voltage.
- .3 Taps: 4 full capacity 2.5% taps
 - 2 below (FCBN) rated voltage
 - 2 above (FCAN) rated voltage
- .4 Impedance: 6.5% impedance at 60 Hz.

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- .5 All winding conductors shall be aluminum.
 - .6 Temperature rise: 115°C with a Class 220 insulation system.
 - .7 Winding arrangements shall be wound with the secondary winding nearest to the core and shall be round coils.
 - .8 The core shall be constructed of high grade, silicon steel laminations, with a step-lap mitre construction for low losses and low sound.
 - .9 The impregnation process for the core-and coil assembly shall include a period under vacuum, followed by pressure impregnation using epoxy resin (EVI process) or alternatively the VPI "Polyester Resin Impregnation Method".
 - .10 The transformer shall be isolated from the enclosure to reduce noise and vibration by means of anti-vibration pads.
 - .11 Electrostatic shield – the transformer shall have an electrostatic shield located between the primary and secondary windings.
 - .12 Sound attenuated enclosure – provide sound attenuated enclosure to < 71 dBA.
 - .13 Transformer's temperature shall be displayed by a digital read-out thermometer, complete with 2 dry contacts.
 - .14 A copper grounding bar shall be installed inside the enclosure and have a minimum of 0.25 x 2.00 inches.
 - .15 The contractor shall connect transformer with the HV switchgear equipment with busbar or flexible links based on site conditions.

PART 3 – TESTS

3.1 PRODUCTION TESTS

Test on the transformer shall include:

- a) Ratio
- b) Polarity and phase-relation
- c) Resistance measurements
- d) No-load losses and excitation current
- e) Load losses and impedance voltage
- f) Applied voltage
- g) Induced voltage
- h) Basic impulse level test
- i) Heat run test.

PART 4 – APPROVED MANUFACTURERS

- Delta Transformers, Inc. Boucherville, PQ, J4B 5Z5
- Atlas Transformers, Inc, Mississauga, Ontario

PART 1 - GENERAL

1.1 Related Work

- .1 Nameplates: Section 16104
- .2 Moulded Case Circuit Breakers: Section 16417.

1.2 Source Quality

- .1 Provide manufacturer's type test certificates indicating switchgear cubicles and components tested as integrated assembly.

1.3 Shop Drawings

- .1 Submit shop drawings in accordance with Section 16010.
- .2 Indicate:
 - INSTALLATION, floor anchoring method and dimensioned foundation template;
 - dimensioned cable entry location;
 - dimensioned cable termination height;
 - dimensioned position and size of busbars and details of provision for extension;
 - dimensioned positions of main connections, including air clearances and support insulators;
 - layout of internal and front panel components suitably identified;
 - time vs current characteristics curves of protection devices.

1.4 Operation and Maintenance Data

- .1 Provide data to be incorporated into installation, operation and maintenance manual.
- .2 Include installation, operation and maintenance data for complete switchgear assembly including components.

1.5 Delivery and Storage

- .1 Ship and store switchgear assembly in upright position.
- .2 Store in weather protected, warm, dry enclosure.
- .3 Keep doors locked and protect instruments from damage and dust.
- .4 Shop channel base sills, anchoring devices in advance of switchgear.

1.6 Short Circuit Study and Relay Coordination Study

The contractor shall provide the following:

- .1 A written statement showing conformance of all equipment supplied can withstand the short circuit levels experience by the equipment.
- .2 Provide all necessary data of electrical panels, fuses, breakers for relay coordination study,

PART 2 - PRODUCTS

2.1 Materials

- .1 Switchgear assembly: to CSA C22.2 No. 31-1977, EEMAC G8-2-1972.

2.2. Rating

- .1 Secondary switchgear: Indoor 600/347V, 3-phase, 4-wire, 60 Hz, minimum interrupting capacity 50 kA (rms symmetrical) or otherwise compliant with short circuit levels indicated through the short circuit study. Amperage rating as specified.

2.3 Enclosure

- .1 Main incoming sections of new switchboards in the new Electrical Room of the Addition to contain:
- Moulded case circuit breakers or air circuit breakers ACB (draw-out type) as indicated;
 - GFI;
 - Volt and ammeters (3 phase);
 - Metering compartment for Toronto Hydro.

The contractor shall submit an alternate bid for a fusible disconnect for non ACB devices.

- .2 Distribution sections of new switchboards to contain:
- moulded case circuit breakers and ACBs sized as indicated;
 - copper bus, from main section to distribution sections including vertical bussing.
 - 24 volt DC power for multi-function relays supplied and installed by others.
- .3 Blanked off spaces for future units.
- .4 Metal enclosed, free standing, floor mounted, dead front, indoor, CSA Enclosure 1 cubicle unit.
- .5 Ventilating louvers: vermin, insect, sprinkler-proof with easily replaceable fiberglass filters.
- .6 Access from front.
- .7 4" (100mm) steel channel sills for base mounting in single length common to multi-cubicle switchboard.
- .8 Provision for future extension on left or right side.
- .9 Sprinkler-proof enclosure.

2.4 Busbars

- .1 3-phase and full capacity neutral bare busbars, self-cooled continuous current rating as specified, extending full width of multi-cubicle switchboard, suitably supported on insulators.
- .2 Joints, Main connection between bus and major switching components to have continuous current rating to match major switching components.
- .3 99.30% conductivity copper for busbars and main connections tin or silver-plated.

- .4 Provision for extension of bus on both sides of unit without need for further drilling or preparation in field.
- .5 Silver surfaced secured with non-corrosive bolts and Belleville washers.
- .6 Identify phases of busbars by suitable marking.
- .7 Busbar connectors, when switchboard shipped in more than one (1) section.

2.5 **Grounding**

- .1 copper ground bus not smaller than 2" x ¼" (50 mm x 6 mm) extending full width of multi-cubicle switchboard and situated at bottom and shall be bolted to each vertical section
- .2 Lugs at each end for size 600 MCM grounding.

2.6 **Circuit Breakers**

- .1 Provide moulded case circuit breakers in accordance with Section 16477.
- .2 Provide air circuit breakers (ACB) as per information shown on the drawings.

2.7 **Instruments and Relays**

- .1 Ground fault protection relay shall be provided as per CSA and ESA requirements.
- .2 The secondary of potential transformers shall be for 120V operation and the secondary of all current transformers shall be for 0-5 amps full range.
- .3 Meter accuracy shall be +/- 1% of range for current and voltage.
- .4 Test blocks shall be located to permit the ready connection of graphic recording meters to measure volts, amps, energy consumption and maximum demand.

2.8 **Cabling Entrance**

- .1 The switchboard assembly shall be arranged to accommodate incoming and outgoing feeders entering and leaving from the top. All bus connectors within the assembly shall be rated not less than the connection bus.

2.9 **Protection**

- .1 Generally, the switchboard assemblies shall be in a CEMA 1 enclosure, except when they are located in sprinkler protected areas in which case, the assemblies shall have approved sprinkler protection.

2.10 **Finishes**

- .1 The assembly shall be factory finished with at least one (1) coat of primer after all surfaces have been properly cleaned, and two (2) finishing coats of the manufacturer's standard switchboard colour.
- .2 Normal power switchboard shall be finished with two (2) coats of manufacturer's standard grey paint.

2.11 **Manufacturers**

- .1 Acceptable manufacturers is Schneider Canada.

(This project is designed with cogeneration in addition to the utility as electrical sources. Therefore, alternative equipment cannot be accepted unless expressly approved by the Engineer/Cogen contractor.)

PART 3 - EXECUTION

3.1 **Testing**

- .1 Each switchboard assembly shall be tested as complete operating entity in the factory prior to shipping.

3.2 **Installation**

- .1 The assemblies shall be shipped to the site in manageable parts and assembled together in the Electrical rooms as designated. Connect all feeders, bus bars, bus duct, to the switchboard and confirm all joints have been properly made prior to energizing. Install all fuses on the site.
- .2 Locate the panelboards as indicated and mount them securely plumb, true and square to all adjoining services.
- .3 Check breaker, fuse sizes and trip unit settings against co-ordination study to ensure proper working and protection of components.
- .4 Provide a continuous rubber mat 40" (1000 mm) wide and 0.24" (6 mm) thick for the full length of the switchboard, in front of all switchboards.

PART 1 - GENERAL

1.1 Conformance

- .1 Conform to Section 16010 "Basic Electrical Requirements".

1.2 Submittals

- .1 Submit product data in accordance with Section 16010.

1.3 Work Included

- .1 The work included under this section covers the supply and installation of disconnect switches up to 600 volts.

1.4 Standards

- .1 Design, manufacture and test all disconnect switches in accordance with good industry practice and in accordance with the following Standards and Codes.
 - .1 CSA Standard C22.2 No. 4 - M1985 Enclosed switches.
 - .2 CSA Standard C22.2 No. 39 - M1987 Fuseholder assemblies.

PART 2 - PRODUCTS

2.1 Disconnect Switches

- .1 Provide heavy duty, quick-make quick-break, load break type `A' industrial rated disconnect switches only.
- .2 Interlock door and switch so that door cannot be opened with the switch in the closed position.
- .3 Provide switches of the fused, or un-fused type as required.
- .4 Provide a non-automatic moulded case circuit breaker as a disconnecting device in lieu of a disconnect switch where recessed mounting is required.
- .5 Provide CSA enclosure 1 or 2 for all disconnect switches to suit location.
- .6 Provide CSA enclosure 3, weatherproof enclosure where exposed to the weather.
- .7 Provide sprinkler proof disconnects in all sprinkler areas.

PART 3 - EXECUTION

3.1 Installation

- .1 Install disconnect switches with fuses as required by Code and as indicated.
- .2 Mount disconnect switches on common fire retardant plywood backboard.

PART 1 - GENERAL

1.1 Standards

- .1 Provide the grounding in accordance with good industry practice and in accordance with the following standards:
 - .1 CSA Standard C22.2 No. 41 - M1987 Grounding and Bonding Equipment.

PART 2 - PRODUCTS

2.1 Equipment

- .1 Provide grounding clamps for grounding conductors of the sizes as required on all electrically conductive underground water pipes, T&B 3902 series.
- .2 Provide copper clad steel ground rods 19 mm (3/4") diameter by 3m (10 ft.) long.
- .3 Provide systems circuit grounding conductors of the sizes as indicated.
- .4 Provide type R90 insulated grounding conductors of the sizes as indicated.
- .5 Provide all non-corroding accessories necessary for the grounding system of the type, size and material as indicated, including but not necessarily to:
 - .1 Grounding and bonding bushings.
 - .2 Protective type clamps.
 - .3 Bolted type conductor connectors.
 - .4 Thermit welded type conductor connectors.
 - .5 Bonding jumpers and straps.
 - .6 Compression wire connectors.

PART 3 - EXECUTION

3.1 Installation - General

- .1 Install a complete, permanent and continuous systems circuit grounding system and an equipment grounding system including electrodes, conductors, connectors, accessories as indicated to conform to the requirements of these specifications and the local authority having jurisdiction over the installation.
- .2 Install the connectors in accordance with the manufacturer's instructions.
- .3 Protect all exposed grounding conductors from mechanical injury.
- .4 Make buried connections and connections to conductive water mains and electrodes using a thermit copper welding process or compression type connectors.
- .5 Use compression connectors for grounding connections to equipment provided with lugs.
- .6 Soldered joints are not permitted.
- .7 Install an RW90 insulated bonding conductor inside each flexible conduit, flexible liquid tight conduit and conduit run with an expansion joint with the conductor connected at both ends to grounding.

- .8 Install a separate grounding conductor in the following:
 - .1 All EMT conduit runs.
 - .2 All PVC conduit runs.
 - .3 All underground or under slab runs.
 - .4 All direct buried runs.
 - .5 All ENT conduits runs.
- .9 Make the grounding connections in a radial configuration only with the connections terminating at a single grounding point at the street side of the water meter. Do not make loop connections except as indicated.
- .10 Bond single conductor, metallic armoured cables to the cabinet at the supply end, and provide a non-magnetic entry plate at the load end.

3.2 **Electrodes**

- .1 Make the ground connections to a continuously conductive underground water pipe at the street slab of the water meter.
- .2 Install a bonding conductor on the water service around water meters, unions and other fittings.
- .3 Install ground rod and make grounding connections as indicated.

3.3 **System & Circuit Grounding**

- .1 Install grounding connections from the exposed, non-current carrying metal parts of equipment included in but not necessarily limited to following:
 - .1 Service equipment.
 - .2 Transformers.
 - .3 Switchgear.
 - .4 Frames of motors.
 - .5 Motor control centres.
 - .6 Starters.
 - .7 Control panels.
 - .8 Disconnect Switches.
 - .9 Distribution panels.
 - .10 Generators
 - .11 Meter Centres

PART 1 - GENERAL

1.1 Work Included

- .1 Provide transformers indicated on plans and as specified herein.

1.2 Product Data

- .1 Submit product data in accordance with Section 01340 and Section 16010.

1.3 Standards

- .1 Dry type transformers to latest revisions of CSA C22.2 No. 47 and CSA-C-802.

PART 2 - PRODUCTS

2.1 Transformers

- .1 Use transformers of one manufacturer throughout project. Marcus, ACME, Squared D, F.P.E. or approved equal.
- .2 Design:
 - .1 Type: ANN as indicated. 1.2 KV Class, 10 KV B.I.L.
 - .2 Transformers shall have primary and secondary copper windings.
 - .3 T-connected winding type are not acceptable.
 - .4 115°C temperature rise insulation system.
 - .5 Enclosure: sprinklerproof construction, removable metal front panel.
 - .6 Finish: grey.
 - .7 Sound ratings:
 - .1 10 to 50 kVa - 45 dB.
 - .2 75 to 150 kVa - 50 dB.
 - .3 225 to 300 kVa - 55 dB.
 - .4 301 to 500 kVa - 60 dB.
 - .5 501 to 750 kVa - 64 dB.
 - .8 Transformers shall have 4 x 2.5% taps. (2 - F.C.A.N. and 2 - R.C.B.N.).

PART 3 - EXECUTION

3.1 Mounting

- .1 Dry type transformers up to 45 KVA may be mounted on wall or suspended on spring isolators from slab.
- .2 Mount dry type transformers above 45 KVA on floor.
- .3 Ensure adequate clearance around transformer for ventilation.
- .4 Provide 25mm thick neoprene vibration isolation pad under each transformer (4 minimum).

3.2 **Connections**

- .1 Make primary and secondary connections with flexible metal conduits.
- .2 Release isolation pad bolts.
- .3 Energise transformers immediately after installation is completed.

3.3 **Equipment Identification**

- .1 Provide lamacoid label stating: ex. "Transformer T2N - 225KVA fed from switchboard, circuit #2, feeding suite distribution ground to 6th floors north".

PART 1 - GENERAL

1.1 Work Included

- .1 Provide all panelboards indicated and scheduled.

1.2 Shop Drawings

- .1 Submit shop drawings in accordance with Section 16010.
- .2 Drawings shall include electrical detail of panel, branch breaker type or fusible switch type as appropriate, quantity, ampacity and enclosure dimensions.
- .3 Table format is not acceptable.
- .4 Panelboards for 120/208 Volt application shall be Schneider (FPL, Square `D'), Siemens, General Electric or Cutler-Hammer.

1.3 Standards

- .1 Panelboards based on CSA C22.2 No. 29

1.4 Plant Assembly

- .1 Breaker Type Panelboards
 - .1 Install circuit breakers in panelboards before shipment.
 - .2 In addition to CSA requirements, manufacturer's nameplate shall show fault current that panel, including breakers, has been built to withstand.
- .2 Switch and Fuse Type Panelboards
 - .1 Assemble panelboard interior before shipment.
 - .2 In addition to CSA requirements, manufacturer's nameplate shall show fault current that panelboard has been built to withstand. The short circuit rating of the panelboards and associated circuit breakers/fuses installed by this contractor must exceed the available short circuit current determined by the Short Circuit Study on the entire building power system undertaken by this contractor.

PART 2 - PRODUCTS

2.1 Panelboards

- .1 Breaker Type Panelboards
 - .1 250V panelboards: bus and breakers rated for symmetrical interrupting capacity at fault level available, as specified by the drawings or as determined by the system coordination study.
 - .2 Sequence phase bussing with odd numbered breakers on left and even on right, with each breaker identified by permanent number identification as to circuit number.
 - .3 Panelboards: mains, number of circuits and number and size of branch circuit breakers as indicated.

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- .4 Provide three (3) keys for panelboards and key panelboards alike.
 - .5 Aluminium bus with full size neutral.
 - .6 Mains suitable for bolt-on breakers.
 - .7 Finish trim and door baked grey enamel.
 - .8 Provide sprinkler shield for all panelboards installed in sprinkler areas.
 - .9 Panels 225 Amp and larger shall have hinged covers.
 - .2 Switch and Fuse Type Panelboards
 - .1 Panelboards and custom built panelboard assemblies: to CSA C22.2 No. 29-M1989.
 - .2 Fuse holder assemblies: to CSA C22.2 No. 39-M1987.
 - .3 Fuses: to Section 16365.
 - .4 Aluminium bus with full size neutral.
 - .5 Panelboard mains suitable for bolt-on fusible disconnect sections.
 - .6 Trim and door finished baked grey enamel.
 - .7 Fusible pull-outs or door-operated type switches shall not be acceptable.
 - .8 Fuse clips shall be suitable for type of fuses specified for each unit.
 - .9 Fuses: sizes as indicated.
 - .10 Provide sprinkler shield for all panelboards installed in sprinkler areas.
 - .11 Panels 225 Amp and larger shall have hinged covers.

2.2 **Breakers**

- .1 Breakers - General
 - .1 Bolt-on moulded case circuit breaker, quick make, quick break type for manual and automatic operation to CSA C22.2 No. 5-M1986 standard.
 - .2 Common trip breakers with single handle for multiple applications.
 - .3 Magnetic instantaneous trip elements in circuit breakers, to operate only when the value of current reaches setting.
- .2 Thermal Magnetic Breakers
 - .1 Moulded case circuit breaker to operate automatically by means of thermal and magnetic tripping devices to provide inverse time current tripping under overload conditions and instantaneous magnetic tripping for short circuit protection.
- .3 Breakers Feeding Fluorescent Lighting
 - .1 All breakers feeding fluorescent lighting shall be suitable for switching duty and shall be marked 'SWD'.

.4 Shunt Trip Breakers

- .1 Provide shunt trip devices, with 120V AC coils unless otherwise indicated, to provide remote tripping where indicated.

2.3 **Equipment Identification**

- .1 Provide equipment identification.
- .2 Nameplate for each panelboard to be engraved, indicating source of power and load controlled.
- .3 Nameplate for each circuit in distribution panelboards, engraved as indicated.
- .4 Complete circuit directory with typewritten legend, showing location and load of each circuit.

2.4 **Compliance**

- .1 All panelboards and circuit breakers must have short circuit ratings that is within the short circuit levels indicated by the short circuit study.

PART 3 - EXECUTION

3.1 **Installation**

- .1 Locate panelboards as indicated and mount securely, plumb true and square, to adjoining surfaces.
- .2 Install surface-mounted panelboards on plywood backboards. Where practical, group panelboards on common backboard, and provide backboards.
- .3 Mount panelboards to maximum height of 2 m (6'-6") or as indicated.
- .4 Connect loads to circuits as indicated. Co-ordinate final designation on-site.
- .5 Connect neutral conductors to common neutral bus with respective neutral identified.
- .6 Lock-on devices shall be installed on all circuits feeding exit lights and emergency lights, fire alarm, security alarm, communication systems and, mechanical equipment where designated. Supply spare devices as shown.

PART 1 - GENERAL

1.1 Work Included

- .1 Starters will be supplied by Division 15 for all motors where indicated on the Drawings and as required for a complete and operational building system. This section is included herein for reference purposes only.

1.2 Submittals By Division 15

- .1 Submit shop drawings, including individual schematic wiring diagrams for each starter, including the following data:
 - .1 EEMAC starter size.
 - .2 Switch sizes.
 - .3 Control transformer size.
 - .4 Terminations for remote devices.
 - .5 Interlocking.
 - .6 Identification of all control components.
- .2 One approved set turned over to Division 16.

PART 2 - PRODUCTS

2.1 General

- .1 All starters shall be provided by the same manufacturer.
- .2 Identify all starters with lamacoid nameplates indicating equipment designation and service.
- .3 Starter enclosures to be sprinkler proof where occurring in sprinkler areas.

2.2 Manual Starters

- .1 Provide single phase manual motor starters of appropriate size and type, including:
 - .1 Quick make and break switching mechanism.
 - .2 Overload heater with manual reset and trip indication sized to match the nameplate full load current of the motor.
 - .3 Neon pilot light.
 - .4 Locate in service rooms or as indicated.
- .2 In finished areas, starters shall be flush mounted with stainless steel covers.

2.3 Magnetic Starters

- .1 Provide combination type magnetic motor starters of size and type as indicated on the Drawings, including:
 - .1 Integral fused quick-make quick-break switching mechanism.
 - .2 Integral 120 V single phase control transformer with fused secondary sized for the control circuit requirements and 25% spare capacity.

- .3 EEMAC 1 enclosure minimum.
- .4 Contactor solenoid operated, rapid action type, EEMAC standard sizes only.
- .5 Motor overload protective device in each phase, manually reset from outside enclosure. Overload heaters shall match nameplate current ratings of motors finally selected and installed, to fully protect the motor for all starting and locked rotor conditions with overloads remaining active at all times.
- .6 Power and control terminals. (Separate terminals for each remote connection to allow for testing isolation of interlock or device.)
- .7 Wiring and schematic diagram inside starter enclosure in visible location.
- .8 Hand-off-auto and speed selector switches.
- .9 Low voltage pilot lights.
- .10 Auxiliary contacts, 2 N.O. and 2 N.C.
- .11 Auxiliary and time delay relays.
- .2 For motors larger than 25 hp, starters shall be of reduced voltage type.
- .3 For motors 22.5 KW (30hp) and larger or with acceleration times in excess of 10 seconds, provide maintained contact thermistor tripping units.
- .4 Mount all start-stop push buttons, selector switches and pilot lights in the starter cover. Label all devices with lamacoid labels.
- .5 Factory wire all starters in accordance with the functions indicated in the Motor Control Schedule. Identify each wire and terminal within the starter with permanent number identical to wiring schematic.
- .6 Provide two speed starters where indicated.

2.4 **Manufacturers**

- .1 Acceptable manufacturers are Schneider (Square 'D'), Cutler-Hammer, Klockner Moeller, General Electric, Siemens and Allen-Bradley.

PART 3 - EXECUTION

3.1 **Installation**

- .1 Install starter, connect power and control wiring as required.
- .2 Ensure correct fuse and overload heater elements are installed.
- .3 Provide unfused disconnect switches where required by the Electrical Safety Code.
- .4 Group starters where multiple units are specified in one area or room. Mount individual or grouped magnetic combination starters on plywood backboards.
- .5 Wire pre-packaged starters provided by Division 15.

- .6 Provide manual starters for all motors up to 1/2 horsepower.
- .7 Contractor shall verify control requirements prior to installation and co-ordinate with DIV. 15.
- .8 Control equipment starters, control panels and isolation disconnect switches installed in areas accessible to the public shall be tamperproof Isolation disconnect switches and control panels shall be pad locked. All locks shall be common keyed.

3.2 Testing

- .1 Operate switches, contactors to verify correct functioning.
- .2 Perform starting and stopping sequences of contactors and relays.
- .3 Check that sequence controls, interlocking with other separate related starters, equipment, and control devices operate correctly.
- .4 Submit individual Shop Drawing for each starter. Have Division 15 review Drawings and indicate each remote device or interlock that is to be wired by Division 15 prior to submission to Consultants.
- .5 Provide relays for shut down of each fan upon actuation of fire alarm system.
- .6 Co-ordinate installation of duct smoke detectors with Division 15.
- .7 Have individual Shop Drawings for starter stamped approved by Division 15 and controls contractor prior to submission. Drawing to be EEMAC Class I Type B.
- .8 Make required revisions to motor schematics as required for interface to Division 15 and controls contractor.

3.3 Power Wiring

- .1 This Division shall perform all power wiring.

3.4 Control Wiring

- .1 Division 15 shall perform all 24 Volt control wiring for equipment supplied by that Division.
- .2 All 120 volt and above wiring shall be performed by this Division.

PART 1 - GENERAL

1.1 General

- .1 Supply and install an engine driven alternator set complete with all auxiliaries, controls, wiring connections and accessories to provide a complete and automatic power unit.
- .2 The unit and installation shall conform to C.S.A. Standard C282-05. The temperature shall not exceed 150°C for Class 'H' insulation.
- .3 All material and equipment shall be new, of current manufacture. All equipment shall be performance certified and warranted against all defective parts and workmanship for a period of one year from the date of acceptance by owners.
- .4 The generator set shall be natural gas.

PART 2 - PRODUCTS

2.1 Engine Driven Alternative Power System

- .1 The unit described herein is based on size as indicated on the design drawings.
- .2 The engine-driven alternator set shall be 347/600 volt 3 phase, 4 wire, 60 cycles, ratings shall be for continuous standby service.
- .3 The alternator and engine shall be permanently aligned by a flexible disc coupling. Both shall operate at a speed of 1800 RPM.
- .4 The Power System shall generally consist of the following items to provide a complete unit capable of operating automatically and unattended on power outages:
 - .1 Natural gas fuel engine with accessories including block heater.
 - .2 Controller.
 - .3 Alternator.
 - .4 Automatic load transfer switch.
 - .5 Starting batteries with stand.
 - .6 Hospital plus grade exhaust silencer with flexible connections to turbo charger and exhaust pipe.
 - .7 Fuel system including flexible fuel lines for connection to unit.
 - .8 Plant exerciser and timer.
 - .9 Unit control panel isolation circuit breaker.

2.2 Engine with Accessories

- .1 The engine shall be 4 cycle, 8 cylinder, turbo charged, after cooled with sufficient bhp at 1800 RPM (as recommended by the engine manufacturer) to power the alternator to full capacity for a period of 24 hours continuously without any damage to the engine. The engine size shall be altitude adjusted as required. Size set 10% overload capability as indicated on design drawings.

2.3 **Cooling System**

- .1 The system shall be water cooled via a plant-mounted radiator. Provide a prelubricated coolant pump, thermostat control, and high engine temperature shutdown.

2.4 **Exhaust System**

- .1 An exhaust pipe of suitable material shall connect the exhaust manifold of the engine to muffler. The muffler system shall be comprised of one hospital plus muffler. It shall be hospital grade, with 2 inches deflection spring set. A flexible section shall be mounted in the exhaust line between the engine and the muffler. Exhaust shall be supplied by this Contractor and installed by Division 15. All supports for muffler by Division 15.
- .2 Due to room size, both the intake and exhaust are equipped with silencers. The manufacturer of generator shall size the radiator fan for a 0.5 inch increase of static pressure.

2.5 **Fuel Systems**

- .1 Natural gas piping, except for supply of flexible connections to engine and the fuel tank will be supplied and installed by Division 15. Division 16 shall coordinate with Div. 15 on the on-site installation work.

2.6 **Lubrication Oil System**

- .1 The lubrication system shall be forced feed gear type pump providing positive full pressure lubrication to all bearings, complete with full-flow oil filter, oil level indicator, oil pressure gauge and low oil pressure engine shutdown.

2.7 **Governor**

- .1 Provide an electronic gear-driven mechanical flyweight governor. Adjustable, speed regulations from no load to rated continuous load shall be 5% maximum complete with automatic over speed shutdown.

2.8 **Starting System**

- .1 The starting system shall be 24 volt, 2 wires complete with gear-engaging starter and including cranking limiter.
- .2 Engine mounted belt-driven alternator 24 volts, 65-amp output with transistorised voltage regulator.

2.9 **Control Panel**

- .1 Wall mounted electric control panel shall be of all-steel design, totally enclosed, with lockable hinged door, C.S.A. approved and shall include the following features:
 - .1A Automatic start/stop system:
 - .1 Automatic starting of the engine upon receipt of signal from the power transfer system and/or by plant exerciser.
 - .2 Automatic bypass of the low oil pressure circuit required at start-up.
 - .3 Automatic shut-down on the following:
 - low lube oil pressure
 - high temperature
 - engine over speed

- overcranking.
- .1B Indicating lights for above four shutdowns and for the following:
 - low temperature
 - low battery level
 - low compressed air level
 - low fuel supply (less than 2-hour supply)
 - engine failure to start (after 3 ten-second cranking attempts).
- .1C Alarm circuit signal (horn).
- .1D Automatic voltage regulator.
- .1E Ammeter and selector switch.
- .1F Voltmeter and selector switch.
- .1G Frequency meter, vibrating reed-type.
- .1H A "Run-Off-Automatic" selector switch.
- .1I Moulded case circuit breaker or breakers (size as indicated on drawings).
- .1J Automatic remote starting capability.
- .1K Signals to fire alarm system to indicate "Generator Running" and "Generator Trouble".
- .2 The panel shall contain all necessary wiring, potential transformers, current transformers, fuses, relays, terminal blocks and a lamp test switch.
- .3 The panel shall contain wiring relays and a common terminal for all 9 indicating lights and "off" position of selector switch for remote monitoring at the Fire Alarm Annunciator as a "Generator Trouble" condition.

2.10 **Automatic Transfer Switches**

- .1 Automatic Transfer Switch shall be Thomson Technologies Inc. or ASCO Electric Ltd. with emergency by-pass isolation switch, or approved equal, mounted in a separate wall mounted cabinet and shall be rated 100% continuous amperes as noted on plans for operation at 0.8 pf. 347/600 volts, 3 phase, 4 wire, 60 cycles, on normal or standby sources. This switch shall transfer the load from normal to emergency when voltage on any one phase falls to 70% or less for three seconds and shall automatically restore power to normal when voltages reaches 90% or more on all three phases for a period of two minutes. When transferring from normal to emergency, an auxiliary contact shall first close the load. Switch shall include a plant exerciser timer for weekly automatic starting to simulate a power failure.

The rating of the transfer switch shall have a fault withstand capacity equal to or greater than available KA asymmetrical current available.

The transfer switch shall have an interrupting and closing rating equal to or exceeding the required withstand rating.
- .2 Include in the transfer switch the following time delay and contactor:
 - .1 Nominal 3-second time delay on engine start and transfer to override harmless power dips and outages. Sound state type.
 - .2 Test switch to simulate normal source failure.

- .3 Auxiliary contact which closes when normal source fails (closes after override delay) (engine start contact).
- .4 Auxiliary contact which closes when normal source fails (open after override delay).
- .5 Auxiliary contact on same shaft as main contact (closed on normal).
- .6 Auxiliary contact on same shaft as main contacts (closed on emergency).
- .7 Full phase protection. Two of the phase relays are nominal 70% to 90% type and one is close differential type factory set for 92% to 95% pickup, 83% to 85% dropout. Solid state type.
- .8 Lockout relay on emergency source, sensitive to voltage and frequency to prevent transfer until the emergency source is approximately at normal voltage and speed. Solid state type.
- .9 Adjustable time delay on retransfer to normal source with 5 minutes unloaded running time of standby plant (motor driven type - minimum setting for retransfer delay is 2 minutes, maximum is 25 minutes. Unloaded plant running time is fixed at 5 minutes). Built-in circuitry automatically nullifies this time delay if the emergency source fails and power is available at normal source. Solid state type.
- .10 Pre and post advance warning time delay.
- .11 Pilot lamps to indicate - "Load on Utility Supply".
- .12 Solid neutral block - full rated.
- .13 Barrier separation between normal, emergency and control power sections.
- .3 Control panel shall be complete with in-phase monitor or neutral time delay function.

2.11 **Starting Batteries**

- .1 Supply 24 volt, minimum 630 ampere cold cranking performance heavy duty lead batteries complete with rack cables, all jumpers and battery stand. Storage batteries shall have a minimum capacity of six ten second cranking attempts at 10°C with a battery end voltage of not less than 80% of the rated voltage.

2.12 **Battery Charging Circuit**

- .1 Control shall contain an adjustable trickle battery charging circuit with millimetre to maintain starting batteries in peak condition and in accordance with the latest edition of C.S.A. Standard C-282.

2.13 **Silencer**

- .1 Silencer shall be hospital plus grade. A copy of the shop drawing shall be submitted to Acoustic Engineer for approval.

2.14 **Cooling Air**

- .1 Radiator cooling air requirements shall not exceed 36,600 CFM.

PART 3 - EXECUTION

3.1 Mounting

- .1 Complete generating assembly shall be rubber shock mounted on a welded steel base which shall be supported on coil-spring steel vibration isolator (Korfound or equal) securely fastened to the floor.

3.2 Installation Requirements

- .1 Prior to acceptance of the installation, CSA-C282-05 tests shall be performed to check that the set will start automatically, pick up load and operate as specified. After all preliminary tests have been made, acceptance test shall be conducted at this Sub-Contractors' expense, to the satisfaction of the Regulatory authority, Engineer or his representative.
- .2 This on site acceptance test shall meet CSA-C282-05 Standards with maximum load, and certified test results shall be submitted in writing for review. Test shall be for four hours at 100% load and then one hour at 100% load continuous.
- .3 A competent engine-alternator expert shall be provided for one working day, at a time convenient to the owners, to instruct owners' staff in the maintenance and operation of the unit.
- .4 Any special tools required for adjustment or maintenance on the alternator set shall be provided, packed in a metal tool box suitable for engine room storage.
- .5 The units shall be the product of a manufacturer regularly engaged in construction of such equipment and shall be Total Power.
- .6 Three copies of the "Manual of Instructions" shall be left in the Generator Room.

PART 1 - GENERAL

1.1 References

- .1 The General Conditions, the Supplementary Conditions, and all Sections of Division 1 apply to and are a part of this Section of the Specification.
- .2 Refer to Section 16010, Basic Electrical Requirements, for instructions which apply to the work of Section 16701, and to Section 16050, Basic Electrical Materials and Methods, for requirements, products and product installation methods that apply to the Work of Section 16701.

1.2 Related Work Specified In Other Sections

- .1 Supply and mounting of fan equipment motor starters with auxiliary contacts for connection into building fire alarm system.
- .2 Leased telephone line for connection of fire alarm system to the local Fire Department or to an outside protection agency - separate arrangement made by the Owner.
- .3 Connection to the guard house monitoring panel.
- .4 Mounting of fire alarm system door holder-closure hardware.

1.3 General Requirements

- .1 These specifications describe the minimum functional requirements for a complete turn-key addressable, electrically supervised, zoned, single stage, non-coded, integrated Fire Alarm and Voice Communication System, complete with sensitivity adjustable smoke sensors and annunciator, and Voice Command Centre. This specification is intended to indicate the type and quality as well as operating features required. The contractor shall submit an alternate price for a semi-addressable system. The contractor shall forward supplier's riser diagrams as part of shop drawings.
- .2 Alternative manufacturer's systems are:
 - 1 Mircom
 - .2 Siemens of Canada
 - .3 Notifier 5000
 - .4 EST (Edwards)
- .3 All work in conjunction with this installation shall meet the provisions of the Ontario Hydro Electrical Safety Code, Underwriters Laboratories of Canada and any applicable local codes.

1.4 Quality Assurance

- .1 Each and all items of the fire alarm system shall be listed as the products of a single manufacturer under the appropriate category by the Underwriter's Laboratories of Canada and shall bear the "U.L.C." label.
- .2 Each and all items of the fire alarm system shall be covered by a one year parts and labour warranty covering defects resulting from faulty workmanship and materials. The warranty shall be deemed to begin on the date the system was accepted by the local authority having jurisdiction.
- .3 All control equipment must have Transient Protection Devices to comply with U.L.C. requirements.

1.5 **Shop Drawings**

- .1 Submit shop drawings in accordance with Section 16010.
- .2 Shop drawings shall include, without being limited to, the following:
 - .1 Control Panel, Annunciator, Alarm in initiating and Signalling Devices complete with catalogue numbers and wiring information.
 - .2 Annunciator and Control Panel zoning.
 - .3 Provide 3 sets of prints for all risers, graphics and panel layouts.

1.6 **As Built**

- .1 Upon completion of the installation and testing, submit to the Consultant 3 copies of all shop drawings, diagrams, operating instructions and descriptive literature, assembled in loose leaf binders identified by Project name.
- .2 As-built layouts marked on a set of building plans indicating panels, annunciators, detectors, pull stations, signals, and conduit routes, wiring information, junction boxes and pull boxes. This shall be provided by the electrical contractor and shall be available on site during the construction period.

1.7 **System Operation**

- .1 System Alarm Operations
 - .1 Fire Alarm Sequence Description
 - .1 Activation of any fire alarm device within the building will result in an alarm on the entire building.
 - .2 Door Control
 - .1 Release the security latches on all electrically locked doors and all door holders upon fire alarm condition where indicated on drawings.
 - .3 Central Station Reporting
 - .1 Activate the City Connect Alarm control point whenever a fire alarm condition exists.
 - .4 Elevator Control
 - .1 If the alarm did not originate from the ground floor, all elevators shall automatically be returned to the ground floor and parked, except designated fire fighter's elevator.
 - .2 If the alarm originated from the ground floor, all elevators shall automatically be returned to the designated alternate floor (not the ground floor) and parked.
 - .5 Fans, Exit Doors and Damper Controls
 - .1 Open all motorised dampers and ground floor exit doors.

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- .2 All stairwell pressurisation fans shall start.
 - .3 Stairwell pressurisation fans shall be controlled by a Delta 'P' sensor such that when a sensor exceeds preset levels, associated fan will stop and only restart when pressure levels decrease. Delta 'P' sensor supplied installed by Div 15. Div 16 shall allocate contacts at door controllers to connect sensor, co-ordinate with mechanical contractor.
 - .4 All fans shall have duct mounted smoke detectors and upon sensing smoke the associated fan will be de-energised. Override controls, shall be installed in the main FACP panel.
 - .5 Stop corridor fresh air unit or units.
 - .6 Provide manual control switches at the Voice Command Centre for the following:
 - .1 Stairwell Pressurisation Fans.
 - .3 Corridor Fresh Air Unit or AHU's
 - .4 Vestibule pressurisation fans.(if applicable)
 - .5 Garage exhaust fans
 - .6 System Reset
 - .1 It shall not be possible to reset the fire alarm system until all the alarms zones have been properly reset or cleared.
 - .7 System Trouble Operation
 - .1 A trouble initiated by the actuation of a Sprinkler Supervisory Valve or Standpipe Valve shall cause the following to occur:
 - .1 An audible and visual LED trouble signal shall latch on at the active graphic annunciator and Fire Alarm Control Panel until acknowledged by an operator at the Fire Alarm Control Panel or Voice Command Centre.
 - .2 Log the Supervisory Trouble Alarm in the Fire Alarm Control Panel's Historical Trouble Log File.
 - .2 Any monitor, speaker or control point wiring trouble, shall cause the following to occur:
 - .1 An audible and visual LED trouble signal shall latch on at the Fire Alarm Control Panel until acknowledged by an operator at the Fire Alarm Control Panel or Voice Command Centre.
 - .2 Log the trouble condition in the Fire Alarm Control Panel's Historical Trouble Log File.
 - .8 Provision for connecting the fire alarm system output to the 'Virtual Concierge'.

PARTS 2 - PRODUCTS

2.1 General

- .1 Fire Alarm System shall be with Voice Communication capabilities. The system shall be a single stage, zoned, non-coded, indicating, non-proprietary fully integrated system, with fully adjustable sensitivity smoke sensors, and a DUAL channel emergency voice communication system. System shall include the following:
 - .1 Fire Alarm Control Panel c/w annunciator.
 - .2 Voice Communication System
 - .3 All Alarm Initiating Devices
 - .4 True Alarm Smoke Sensors (c/w fully adjustable sensitivity)
 - .5 All Signal Devices
 - .6 All programmed delays for ancillary controls.
- .2 Fire alarm control panel shall allow for loading or editing of special instructions and operating sequences as required. The system shall be capable of on site programming to accommodate and facilitate expansion, building parameter changes or as required by local codes. All software operations shall be stored in a non-volatile programmable memory within the fire alarm control panel. Loss of primary and secondary power shall not erase the instructions stored in memory.
- .3 Ability to selectively program input/output control functions and special coded operations shall be incorporated into the resident software programming of the system.
- .4 Initiation circuits shall be individually configurable on site to provide either alarm/trouble operation, alarm only, trouble only, non-alarm, a non-latching monitoring circuit or an alarm verification circuit.
- .5 System shall be equipped with a built in RAM buffer which will store up to 300 alarms and 300 trouble conditions in chronological order under two separate files. The alarm log file must be separate from the trouble log file.
- .6 System shall have an alarm list key that will allow the operator to display all alarms, troubles, and supervisory service conditions with the time of occurrence.
- .7 System shall have provisions for disabling and enabling all circuits individually for maintenance or testing purposes. Capability must be password protected.
- .8 All smoke sensors shall be programmed to perform the alarm verification sequencing as required.
- .9 All on site programming changes to the fire alarm system shall be password protected. **DURING THE CONSTRUCTION STAGE, ALL PROGRAM AND CUSTOM LABEL CHANGES SHALL BE APPROVED IN WRITING BY THE CONSULTANT.**
- .10 All system controls shall be housed in surface wall mounted steel cabinets, complete with systems beige finish.
- .11 All modules and annunciator indicators shall be secured behind a hinged locked door with a full viewing tempered glass window. The hinged locked doors shall give access to all the operating controls but shall not expose live connections.
- .12 All internal wiring, control circuits, connections and terminals shall be accessible from the front of the panel.

- .13 A trouble/alarm c/w silencing switch indicator must be provided at the concierge desks which shall illuminate and an trouble signal shall sound at the control panel upon the detection of an open, ground condition, alarm or supervision condition.
- .14 All Cabinets are to be properly grounded to building ground. Conduit ground will not be acceptable. The green coloured ground loop shall be a minimum #10 AWG. insulated copper run in conduit. Ground wire must not be run in the same conduit as the Fire Alarm and Communication wiring.

2.2 Fire Alarm Control Panel

- .1 Fire alarm control panel construction shall be modular in design with solid state microprocessor based electronics. An 80 character Liquid Crystal Display shall indicate alarms, supervisory service conditions and any troubles. The panel shall include but not be limited to the following:
 - 80 character LCD display
 - Speaker Circuits
 - Supervised Annunciator Circuits
 - Basic 8 Amp power supply
 - Automatic Battery Charger
 - Standby Batteries
 - Resident non-volatile programmable operating system memory for all operating requirements
 - Two RS-232-C I/O Ports
 - Five Programmable multifunction keys with status LED's
 - Red alarm LED and acknowledge button
 - Yellow supervisory service LED and acknowledge button
 - Green power on LED
 - Operator interface keypad for manual control and system information access
 - Loop Modules capable to communicate to 127 devices
- .2 All auxiliary manual controls shall be supervised so that all switches must be returned to the normal automatic position to clear system trouble.
- .3 System Expansion Modules connected by ribbon cables shall be supervised for module placement. Should a module become disconnected from the CPU the system trouble indicator must illuminate and audible trouble signal must sound.
- .4 Speaker circuits shall be independently supervised and fused such that a fault on one circuit shall not affect the operation of other speaker on that circuit or any of the other circuits. All speaker zones shall be configured as follows:
 - .1 Class "A" wiring, current limited
 - .2 Rated at two amps of continuous power
 - .3 One circuit for each zone at floor levels as shown on drawings.
- .5 Provide dry contact auxiliary control circuits as follows:
 - .1 Central Station alarm output
 - .2 Central Station trouble output
 - .3 Four fused .5 amp (120 VAC) Form C misc. control relays
- .6 Fire Alarm Control Panel shall be capable of supporting 5 RS-232-C I/O ports. CPU data output to the I/O ports shall be in a parallel ASCII format at field adjustable baud rates of 220, 300, 1200, 2400 and 4800. Supply minimum of two.
- .7 The control panel shall receive 120/240 VAC power via a dedicated circuit.

- .8 Incoming power to the system shall be supervised so that any power failure must be audibly and visually indicated at the control panel and the remote active graphic annunciator. A green 'Power On' LED shall be displayed continuously while incoming power is present.
- .9 Control panel power supply shall have the following operating characteristics:
 - .1 Rated for ten amps continuous duty (on CPU).
 - .2 Sufficiently sized to power all remote system components plus adequate spare capacity to power no less than 20% additional devices.
 - .3 24 VDC filtered and regulated.
 - .4 Power limited with a range of 20.4 VDC to 32 VDC.
 - .5 Automatic "Brownout" transfer to standby batteries when supply voltage reaches 102 VAC.
- .10 System shall be provided with sufficient battery standby capacity to operate the entire system on batteries upon loss of normal 120 VAC power in a normal supervisory mode for a period of twenty-four hours with two hours of alarm operation at the end of this period. The system shall automatically transfer to the standby batteries upon power failure. All battery charging and recharging operations shall be automatic.
- .11 System batteries shall be supervised so that a low battery condition or disconnection of the batteries shall be audibly and visually annunciated at the control panel.
- .12 Control panel battery charger shall have the following operating characteristics:
 - .1 Ability to charge batteries to 70% of their capacity within 12 hours.
 - .2 Compatible with either lead acid or nicad batteries.
- .13 All circuits requiring system operating power shall be individually fused at the control panel.
- **.14 Fire alarm Panel requires "IP Addressable" notification system enabling off site viewing only. System cannot be silenced remotely.**

2.3 Control Panel Operation and Capabilities

- .1 History Logging
 - .1 System shall be capable of logging and storing 300 events in an alarm log and 300 events in a trouble log. These events shall be stored in a battery protected random access memory. Each recorded event shall include the time and date of that event's occurrence.
 - .2 Following Historical Alarm log events shall be stored:
 - .1 Alarms
 - .2 Alarm Acknowledgement
 - .3 Alarm Silence
 - .4 System Reset
 - .5 Alarm Historical log cleared
 - .3 Following Historical Trouble log events shall be stored:

- .1 Trouble conditions
 - .2 Supervisory alarms
 - .3 Trouble acknowledgement
 - .4 Supervisory acknowledgement
 - .5 Alarm Verification tallies
 - .6 Walk Test results
 - .7 Trouble Historical log cleared
- .2 System Walktest
 - .1 System walk test feature shall be provided in compliance with all applicable codes and regulations subject to the approval of local authorities having jurisdiction.
 - .2 Provide all the necessary software and/or equipment to provide the following **ONE-MAN SYSTEM TESTING PROCEDURE:**
 - .1 Initiating the walktest mode shall automatically disconnect the central station and auxiliary control circuit relays, and create a system trouble indication on the control panel.
 - .3 Alarm activation of any initiating device shall annunciate the alarm zone over all signal circuits identifying the zone of alarm to the test technician without having to return to the fire alarm control panel.

e.g. Pull station pulled on zone # eight; all speakers will sound:

"TEST.....ZONE EIGHT"
 - .4 After the testing of the device and the sounding of the zone number, the system shall automatically reset itself, and await the next device to be tested.
 - .5 Any momentary opening of an initiating or indicating appliance circuit shall cause the speakers to indicate the trouble condition.

e.g. Disconnect the zone wiring to zone # 9; all speakers will sound:

"TROUBLE.....ZONE NINE"
 - .6 Actuation of the Walktest program shall not require any special tools or programming knowledge by the owner or operator.
- .3 Silent Walktest with History Logging
 - .1 System shall also be capable of being tested by one person in a **SILENT MODE**. While in testing mode the alarm activation of an initiating device circuit shall be silently logged as an alarm condition in the historical data file. The panel shall automatically reset itself after logging of the alarm.
 - .2 Momentary disconnection of an initiating or indicating device circuit shall be silently logged as a trouble condition in the historical data file. The panel shall automatically reset itself after logging of the trouble condition.
 - .3 Should the Walktest feature be on for an inappropriate amount of time it shall revert to the normal mode automatically.
 - .4 Control panel shall be capable of supporting up to 8 separate testing groups

whereby one group of points may be in a testing mode and the other (non-testing) groups may be active and operate as programmed per normal system operation. After testing is considered complete, testing data may be retrieved from the system in chronological order to ensure device/circuit activation.

.4 Normal Operating Conditions

- .1 Under normal condition the front panel shall display a "System is Normal" message and the current time and date.
- .2 Should an abnormal condition be detected the appropriate LED (Alarm, Supervisory or Trouble) shall flash. The panel audible signal shall pulse for alarm conditions and sound steady for trouble and supervisory conditions.
- .3 The LCD shall display the following information relative to the abnormal condition of a point in the system.
 - .1 40 character custom location label
 - .2 Type of device (i.e. smoke, pull station, water flow)
 - .3 Point status (i.e. alarm, trouble)
 - .4 Pressing the appropriate acknowledge button shall display the first unacknowledged condition in the appropriate list (either alarm, supervisory or trouble), and require another acknowledge button. Press to acknowledge only the displayed point.
 - .5 After all points have been acknowledged, the LED's shall glow steady and the Sonalert will be silenced. The total number of alarms, supervisory and trouble conditions shall be displayed along with a prompt to review each list chronologically. The end of the list shall be indicated by an end of list message "END of LIST".

.5 Alarm Silencing

- .1 Should the "Alarm Silence" button be pressed all alarm signals shall cease operation, as required by Ontario Building Code.
- .2 Signals shall not be silenced during alarm silence inhibit mode.

.6 System Reset

- .1 The SYSTEM RESET button shall be used to return the system to its normal state after an alarm condition has been remedied. The LCD display shall step the user thru the reset process with simple English Language messages. Messages, "SYSTEM RESET IN PROGRESS" will first be displayed followed by the message, "SYSTEM RESET COMPLETED", and finally, "SYSTEM IS NORMAL", should all alarm conditions be cleared.
- .2 Should an alarm condition continue to exist the message, "SYSTEM RESET IN PROGRESS", will be followed by the message, "SYSTEM RESET ABORTED", and the system will remain in an abnormal state. System control relays shall not reset. The Sonalert and the Alarm LED will be on. The display will indicate the total number of alarms and troubles present in the system along with a prompt to use the ACK keys to review the points. These points will not require acknowledgement if they were previously acknowledged.

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- .3 Should the Alarm Silence Inhibit function be active, the (SYSTEM RESET) key press will be ignored. The message, "SYSTEM RESET INHIBITED", will be displayed for a short time to indicate the action was not taken. As feedback to the operator, the message "SYSTEM RESET NO LONGER INHIBITED" will be displayed when the inhibit function times out.
- .7 Function Keys
- .1 Additional function keys shall be provided to access status data for the following points:
- .1 Initiating device circuits
- .2 Indicating appliance circuits
- .3 Auxiliary relays
- .4 Feedback points
- .5 All other input/output points
- .2 Following status data shall be available:
- .1 Primary State of point
- .2 Zone, PID and Card type information
- .3 Class "A" Status
- .4 Current priority of outputs
- .5 Disable/Enable status
- .6 Verification tallies of initiating devices
- .7 Automatic/Manual Control Status of output points
- .8 Acknowledge status
- .9 Relay status
- .8 System Trouble Reminder
- .1 Should a trouble condition be present within the system and the audible trouble signal silenced, the trouble signal shall resound at pre-programmed time intervals to act as reminder that the fire alarm system is not 100% operational. Both the time interval and the trouble reminder signal shall be programmable to suit the owner's application.
- .9 Access Levels
- .1 There shall be four (4) access levels with level 4 being the highest level. Level 1 action shall not require a pass code. Pass codes shall consist of up to ten (10) digits. Changes to pass codes shall only be made by authorised personnel.
- .2 In order to maintain security when entering a pass code the digits entered will not be displayed but a cursor will move along filling the position with an X to indicate that the digit has been accepted. All key presses will be acknowledged by a local audible sound.
- .3 When a correct pass code is entered, the message "Access Granted" shall be displayed. The new access level shall be in effect until the operator manually logs out or the keypad has been inactive for ten (10) minutes.
- .4 Should an invalid code be inputted, the operator shall be notified with the message, "ERROR....INCORRECT PASSCODE", and shall be allowed up to three chances to enter a valid code. After three unsuccessful tries, the message, "ACCESS DENIED", shall be displayed. The level shall not be altered, and the operator shall no longer be in the menu option.

- .5 Access to a level will only allow the operator to perform all actions within that level plus all actions of lower levels, not higher levels.
- .6 The following keys/switches shall have access levels associated with them:
 - Alarm Silence
 - System Reset
 - Set Time/Date
 - Manual Control
 - On/Off/Auto Control
 - Disable/Enable
 - Clear Historical Alarm Log
 - Clear Historical Trouble Log
 - Walk Test
 - Change Alarm Verification
- .7 Acknowledge keys shall also require privileged access to acknowledge points. If the operator presses an (ACK) key with insufficient access, an error message will be displayed. The points will scroll with (ACK) key presses to view the points on the list, but the points will not get acknowledged in the database.

2.4 Auxiliary Fan and Damper Control System

- .1 Provide the following indicators and switches with functions indicated in a semi-recessed enclosure where shown on drawings.
 - .1 One green LED for each auxiliary control circuit to give positive indication that the fan or damper has been activated.
 - .2 One switch for each auxiliary control circuit to allow individual selection of the fan or damper circuits.
 - .3 Refer to Electrical drawings for the list of circuits to be provided.

2.5 Fire Alarm Devices

- .1 Pull Stations
 - .1 Pull stations shall be single action, non-coded, one state, flush mounted type. Pull stations shall be break glass, key locked and have one set of sealed N/O contacts.
- .2 Heat Detectors
 - .1 Automatic thermal detectors shall consist of a cast metal junction box and cover of special design. Activation of the fixed temperature element in the detector shall cause the centre disc to drop into a vertical position to provide a visible means of determining which detector has initiated the alarm. Refer to drawings for quantity of thermal detector. The type of detectors required shall be:

135 (or 200) Deg. F, Fixed Temperature and Rate of Rise
- .3 Area Smoke Detectors
 - .1 Photoelectric detectors shall be solid state in design operating on the light scattering principle. Detectors shall have a completely closed back to restrict entry of dust and air turbulence. Detector electronics shall be completely

shielded to protect against false alarms from EMI and RFI. Detector LED shall pulse to indicate power on and glow continuously when in alarm.

- .2 Ionisation detectors shall be solid state and of the dual chamber design. Detector shall have a completely closed back to restrict entry of dust and air turbulence. Detector electronics shall be completely shielded to protect against false alarms from EMI and RFI. Detector LED shall pulse to indicate power on and glow continuously when in alarm.
- .3 To minimize false alarms, all detector heads shall be designed with voltage and RF transient suppression techniques, smoke signal verification circuits and an insect screen.
- .4 Provide twist lock mounting bases with locking tamper screw that are compatible with the either Photoelectric or Ionisation smoke detectors. Smoke detector bases shall allow for the removal of the detector head without disturbing the zone wiring.
- .5 Automatic smoke detectors shall be equipped with a dust-bag, which shall be removed at the time of verification to prevent dust and dirt entering the smoke chamber during construction.

.4 Duct Smoke Detectors

- .1 Duct smoke detector assemblies shall come complete with duct housing, Photoelectric smoke detector head and sampling tubes as required. The duct housing base shall come complete with an auxiliary set of form C dry contacts rated at 120 VAC, 3 amps and terminals for a remote lamp unit.
- .2 Duct housing assembly shall consist of an air tight housing mounted on the side of the duct. This housing shall contain a detector base into which an appropriate detector head is inserted.

.5 End-Of-Line Resistors

- .1 End-of line resistors for alarm and signalling circuits shall be sized to ensure the correct supervisory current flows in each circuit.
- .2 End-of-line resistors shall be mounted on a stainless steel plate for mounting on a standard single gang plate and bear the ULC label.

.6 Vestibule Annunciator (Where Required)

- .1 Provide multiplex annunciators where shown or required on the drawings. Each annunciator shall have the ability to add or delete zones without adding or deleting wires.
- .2 Refer to drawings for the list of zones to be annunciated.

.7 Zone Isolators

- .1 Provide zone isolators where the loop enters and leaves a fire separation/zones as required by NFPA 70 and relevant Ontario Fire Code, ULC Codes.

3.1 **Low Voltage Conductors**

- .1 Wires and cables as per Section 16120 and section 32 of the Ontario Electrical Safety Code.
- .2 Install the fire alarm/voice communications system to the equipment manufacturers requirements.
- .3 Provide end of line devices for all circuits as recommended by the manufacturer.
- .4 All wiring for fire alarm system monitoring, control and communication circuits shall be installed in conduit. When pulling wires into conduit, use lubricant and ensure that wires are kept straight and are not twisted or abraded.
- .5 All wires must be clearly identified at all termination points. In addition they shall be numbered with Brady Ltd. or Electovert Ltd. Z-type markers.
- .6 Colour conductors for each part of the system in accordance with the system equipment manufacturer's recommendations.
- .7 Provide engraved lamaroid identification nameplates for each equipment or wiring housing and secure to the front of the housing. Exact wording designations and sizes to be reviewed and confirmed with the project manager prior to manufacture.
- .8 In addition to wiring connections to fire alarm system components, install devices and wiring in conduit from the fire alarm control panel as follows:
 - .1 To motor branch circuits for designated supply fans to start the fans upon activation of the fire alarm system. Provide a double voltage relay for each motor circuit.
 - .2 To fire protection system (standpipe and sprinkler) supervised O.S.&Y. valve contacts and sprinkler alarm and trouble contacts to activate the system as previously described.
 - .3 To a pressure switch in the building water service main to initiate a "LOW CITY WATER PRESSURE" trouble alarm on supply side of booster pump.
 - .4 To the sprinkler system excess pressure pump motor starters to initiate an "EXCESS PRESSURE PUMP LOSS OF POWER" trouble alarm.
- .9 Do NOT wire any 120 volt circuits in the conduit containing low voltage fire alarm circuits.
- .10 Fire rating requirements of all wires shall be confirmed by local authority having jurisdiction.

3.2 **Zone Labels**

- .1 Verify nomenclature of the annunciator identification with the **CONSULTANT** and obtain necessary approvals prior to ordering.

3.3 **Installation of Alarm Initiation Devices**

- .1 Provide all required manual pull stations, thermal detectors and products of combustion detectors.
- .2 Install manual pull stations with a standard 100 mm recessed outlet box with plaster

rings, except in the unfinished areas where the pull stations must be surface mounted, in which case, install the stations in surface mounted box. Ensure that pull stations in flammable storage areas are explosion-proof and pull stations outside the building are weatherproof. Refer to the floor plans and drawing symbol list to determine the type of pull station in any give area.

- .3 Install the mounting plate of thermal detectors to ceiling mounted 100 mm octagon boxes. Secure the detectors to the plates. Ensure that thermal detectors in flammable storage areas are explosion - proof. Refer to the floor plans and drawing symbol list to determine the type of detectors in any given area.
- .4 Secure the base of each ceiling mounted product of combustion detector to a 100 mm outlet box, either flush or surface mounted as required. Secure detector heads to the bases. Where shown on the drawings, provide wiring in conduit from patient's room products of combustion detectors to nurse call system dome light **RED** lamps.
- .5 Mount each duct mounted products of combustion detector on the duct in question and connect with smoke sampling tubes which extend into the duct stream. Install a remote alarm LED assembly on a standard single gang box for each duct detector. Confirm location of detector and LED's with consultant and SIMPLEX prior to installation. Do not locate duct detectors within 1m of duct size increaser or decreaser fittings or any elbow. Refer to drawings and schedules for quantity of duct detectors required at each location.

3.4 Testing Verification and Certification

- .1 The manufacture shall make an inspection of the fire alarm equipment, including those components necessary to the direct operation of the system such as manual stations, thermal detectors and controls, whether or not manufactured by the manufacturer. The inspection shall comprise an examination of such equipment for the following:
 - .1 That the type of equipment installed is that designated in the specifications.
 - .2 That the wiring connections to all equipment components shown that the installer undertook to have observed ULC and CSA requirements.
 - .3 That the equipment has been installed in accordance with the manufacturer's recommendations, and that all signalling devices have been operated or tested to verify their operation and
 - .4 That the supervisory wiring of those items of equipment connected to a supervised circuit is operating and that the governmental regulations, if any, concerning such supervisory wiring, have been met to the satisfaction of inspecting officials.
- .2 The manufacturer shall supply reasonable amounts of technical assistance with respect to any changes necessary to conform to the above. During the period of inspection by the manufacturer, make available to the manufacture electricians as required.
- .3 The Fire Alarm System installation shall be verified in accordance with the requirements of ULC/CAN standard S537-M86. Open flame and smoke are not be used in testing.
- .4 All testing must be witnessed by Owner's representative, prior to acceptance.
- .5 On completion of the inspection and when all of the above conditions have been complied with, the manufacturer shall issue to the Consultant:
 - .1 A copy of the inspecting technician's report showing location of each device and

certifying the test results of each device.

- .2 A certificate of verification confirming that the inspection has been complete and showing the conditions upon which such inspection and certification have been rendered.
- .3 Proof of liability insurance for the inspection.
- .4 Submission of system manuals with final test results.
- .6 Inspection Costs
 - .1 All costs involved in this inspection shall be included in the tender price.
- .7 Since differences exist between manufacturers, some changes may be required relative to conduit system, system components configuration and layout and type of wiring. These shall be included in the tender price, at no additional cost to the Contract.

3.5 **Training**

- .1 When verification and commissioning are complete, arrange for the system manufacturer to visit the site and demonstrate proper operation and maintenance of the alarm system to designated members of the building operating and maintenance staff. Also include the owner's designated representatives in all aspects of the operation and maintenance of system and equipment.
- .2 Provide 24 hours of training on or off-site to as many as five owner's representatives. The owner may request this training at any time during the warranty period and in 8 hour intervals.
- .3 Include in the tender price for the cost of the manufacturer's services of qualified service technicians and other manufacturer's representatives required for this instruction. Include for re-verification due to partial occupancy verification.
- .4 Submit to the project manager prior to applying for SUBSTANTIAL PERFORMANCE of the project, a complete list of the instructions that were given, stating:
 - .1 Date instructions were given to the owner's staff;
 - .2 Duration of the instruction;
 - .3 Names of the person's instructed;
 - .4 Parties present (e.g. manufacturer's representative, project manager etc.)
- .5 Obtain the signature of the Owner's designated representative to verify the system operation and maintenance procedures have been received. The required number of operating and maintenance manuals and record as-built drawings must also be confirmed as received.

PART 1 - GENERAL

1.1 **General**

- .1 Supply and install an Emergency Elevator Communication System providing two way communication from each fire alarm annunciator panel. The System shall consist of a Master Handset capable of individually calling up to each elevator cab. It shall be enclosed in a locked steel enclosure as an integral part of the CACF panel. It shall be complete with low voltage power supply connected to the building emergency electrical power system. The elevator cab station shall be a Hands Free Duplex Communication System installed in each cab by the elevator supplier. All wiring shall be shielded twisted pairs of wire gauge as per Manufacturers' Specifications. Minimum number of conductors shall be 3 common and 1 selective to each elevator cab from the Master Phone.
- .2 Supply and install a dedicated phone line to the elevator machine room or control closet as per the elevators' suppliers specifications.

PART 1 - GENERAL

1.1 **General**

- .1 Supply and install a system of empty conduits with pull strings as indicated on the riser diagrams and as per information provided by the security contractor. The security device locations will be roughed-in by the electrical contractor.
- .2 Supply 120 V power to security desk at concierge and at security backboard and enterphone backboards.
- .3 Supply 120V power to all door operators.
- .4 Supply 120V power to the audio amplifier and DVD player where indicated on drawings.

PART 1 - GENERAL

1.1 **General**

- .1 Incorporate the CT compartments as indicated on the drawings into panelboards and install CT's into the CT compartment.
- .2 Provide empty conduits and necessary power wiring for the digital metering system as supplied and installed by Provident Energy as per details described on the drawings.

PART 1 - GENERAL

1.1 General

- .1 Supply and install a system of empty conduits with pull strings that extend from the control panels at the garbage rooms to all the garbage intake rooms.
- .2 Provide 208V, 3 phase power to the Trisorter operators and compactors, size of the breaker to be as per supplier's specifications.
- .3 Provide necessary 120V power for Trisorter control to the supplier's specifications.
- .4 Provide junction boxes at each garbage intake room as specified by the Suppliers of the equipment.
- .5 Provide 120V power wiring to all control panels as specified by the Suppliers' Shop Drawings.

1.2 Electrical Requirement for Trisorter Systems

- .1 Supply and install 120V, 1 phase, 20A for recycling system Master Control Panel (MCP) for the Trisorters.
- .2 Provide 1 receptacle connected to a dedicated 120V, 15A, 1P circuit for maintenance.
- .3 Provide **208V, 3 phase, 4 wire 20 Amp power feed with neutral** to compactor circuit.
- .4 Provide junction boxes at each garbage intake room as specified by the Suppliers.
- .5 Provide 1" EMT conduit for vertical installation through the garbage intake chute for connecting Tri-sorter control panel, chute intake door control panel and other elements indicated on the shop drawings.
- .6 Consult Tri-sorter supplier prior to installation of the conduit system mentioned in .4

1.3 Electrical Requirement for Manual Feed Waste Compactors and Balers

- .1 Supply and install 120V, 1 phase, 20A for recycling system Master Control Panel (MCP) for the tri-sorters. Provide a safety disconnect switch upstream of the MCP.
- .2 Provide one receptacle connected to a dedicated 120V, 15A, 1P circuit for maintenance per system.
- .3 Provide 600V, 3 phase, 3 wire 20 Amp power feed to the compactor circuit.
- .4 Provide junction boxes at each garbage intake room as specified by the Suppliers.
- .5 Provide 1" EMT conduit for vertical installation through the garbage intake chute for connecting tri-sorter control panel, chute intake door control panel and other elements indicated on the shop drawings.
- .6 Provide 2 disconnects within 5 feet of the garbage chute (1 for the compactor, 1 for the Tri-sorter Control Panel).
- .7 Consult the tri-sorter supplier prior to installation of the conduit system mentioned in .4.

1.4 **Shop Drawings**

- .1 Submit all suppliers of the waste disposal systems to the Engineer prior to installation and wiring of the systems.

PART 1 - GENERAL

1.1 General

- .1 Supply and install a complete CO monitoring system in the parking levels of the building.
- .2 The system shall include a control panel, sensors, conduits 120V power and control wiring.
- .3 Provide testing and commissioning to ensure that an operational system that satisfies all the inspection authorities is delivered.

PART 2 – PRODUCTS

2.1 Equipment

- .1 The CO system shall be made by Honeywell Vulcain Inc., QEL or another equivalent product approved by the Engineer.

2.2 Shop Drawings

- .1 Shop drawings shall be submitted to the Engineer prior to release for purchase.

2.3 Test Report

- .1 Submit test reports to the Engineer as part of the supporting documents for occupancy.

PART 3 – EXECUTION

2.4 Zoning

- .1 The CO system shall be zoned on a per floor basis.

2.5 Sequence of Operation

- .1 If one of the sensor in a zone (floor) sensed its CO level to be above the minimum threshold of 2.5 ppm, it will activate all the exhaust fans associated with that zone (floor) to be turned on.

PART 1 - GENERAL

1.1 General

- .1 Supply and install a complete NO monitoring system in the loading dock areas of the building for monitoring nitrous oxide (NO₂) gases.
- .2 The system shall include a control panel, sensors, conduits 120V power and control wiring.
- .3 Provide testing and commissioning to ensure that an operational system that satisfies all the inspection authorities is delivered.

PART 2 – PRODUCTS

2.1 Equipment

- .1 The NO system shall be made by Vulcain Inc. or another equivalent product approved by the Engineer.

2.2 Shop Drawings

- .1 Shop drawings shall be submitted to the Engineer prior to release for purchase.

2.3 Test Report

- .1 Submit test reports to the Engineer as part of the supporting documents for occupancy.

PART 1 - GENERAL

1.1 Related Work

- .1 General Provisions: Section 16010
- .2 Basic Materials and Methods: Section 16050

1.2 Work Specified in Other Sections

- .1 Related work in other Sections is as follows.
- .2 Division 9, Cutting of ceiling and installation of plaster rings or trims.

1.3 Scope

- .1 The work of Division 16 shall include the installation of all lighting fixtures, lamps and accessories, together with the necessary co-ordination with other Divisions to provide a complete and operable lighting system.
- .2 Lighting fixtures will be supplied by owner.
- .3 Contractor shall notify the owner in a timely manner when fixtures or mounting hardware will be required. Contractor will be responsible for receiving and storing fixtures.
- .4 Contractor shall provide a functional occupancy sensing, and where appropriate, daylight harvest.

1.4 Shop Drawings

- .1 Shop Drawings, as specified under Section 16010, shall be supplied by the owner's supplier for all lighting fixtures.

PART 2 - PRODUCTS

2.1 Fluorescent Fixtures, Ballast and Lamps

- .1 All fluorescent fixtures shall be equipped with high frequency, instant start electronic ballasts for operation on 120 Volts, unless specifically noted otherwise.
- .2 Ballasts shall be high power factor electronic complete with non-automatic reset, type thermal protection as defined by C.S.A. and shall have sound rating "A".
- .3 Unless otherwise noted, all fluorescent lamps shall be rapid start, energy saving, Octron T8, 5000°K, rated 20,000 hours or as shown on the drawings, and providing 2900 initial lumens (minimum), or less specifically noted otherwise.
- .4 Compact fluorescent lamps shall be Quad tube, 5000°K colour or as shown on the drawings, 10000 hours life expectancy.
- .5 Lamps shall be guaranteed for a period of twelve (12) months from the date of acceptance of the work under this contract. Labour for replacing lamps shall be included in the guarantee.
- .6 Lamps shall be as manufactured by Canadian General Electric, Osram, Philip.

- .7 All ballasts shall meet the specifications and requirements of the Electrical Testing Laboratories, and Certified Ballast Manufacturer's Association.

2.2 **Incandescent Fixtures and Lamps (for information only)**

- .1 All incandescent fixtures shall be provided with medium base, 125 Volt, inside frosted lamps, rated 2500 hours, except where noted otherwise, and of wattage accommodated by the fixture.
- .2 Reflector lamps shall be rated for 2000 burning hours lamp life.
- .3 Incandescent lamps shall not generally be provided unless explicitly specified in the drawings.
- .4 Lamps for exit lights shall be 7 watt compact fluorescent.

2.3 **H.I.D. Fixtures, Ballast and Lamps**

- .1 All high intensity, discharge fixtures shall be equipped with high power factor, constant wattage, 120 Volt ballasts or 347 volts, unless specifically noted otherwise.
- .2 Ballast for use outside the building shall provide reliable starting down to -22°F for metal halide, and high pressure sodium lamps.
- .3 H.I.D. ballast shall meet the requirements of the Electrical testing Laboratories and Certified Ballast Manufacturer's Association.
- .4 Unless noted otherwise, H.I.D. lamps shall be manufactured by Canadian General Electric, Osram, or Phillips.

2.4 **General Lighting Fixture Requirements**

- .1 Quality: Install only lighting fixtures which are structurally well designed and constructed, and which use new parts and materials of highest commercial grade available.
- .2 Matching Ceiling and Fixture Finishes: Verify the finish of exposed ceiling support members and tiles, before ordering fixtures, and paint fixtures to match, where required in the specifications or drawings.
- .3 Manufacturer's Operational Tests:
 - .1 Test fixtures for acceptance of lamp make to maximum tolerance as required in A.N.A. Standards as listed in Section 16
 - .2 Test fixtures with rated lamps for starting and operation.
 - .3 Check wiring for agreement with design circuit.
 - .4 Test for short circuits and improper grounds.
- .4 Commercially Listed Fixtures:
 - .1 Lighting fixtures shall be of the types, sizes, ratings, etc., shown in the Fixture schedule and notes therein, and shall be in accordance with the details shown on the drawings.

- .2 Provide wherever possible, commercially available stock lighting fixtures which meet the requirements of the specified fixtures. Obtain approval from the Engineer, in writing, for the alternate fixture types submitted.
- .5 Delivery: Assemble completely all fixtures at the manufacturer's plant and deliver to the project site in original cartons. Ensure that a dry and protected space is available for proper storage before delivery of production fixtures.

2.5 **Hangers and Fittings**

- .1 General:
 - .1 Support fixtures as shown on the drawings, level, plumb and true with the structure and other equipment, and in a horizontal or vertical position as intended.
 - .2 Wall or side bracket mounted fixture housings shall be rigidly installed adjusted to give a neat flush fit to the surface on which it is mounted.
 - .3 All hangers, supports, fastenings or accessory fittings shall be protected against corrosion. Care shall be taken during the installation to assure that insulation and corrosion protection is not damaged.
- .2 Supports
 - .1 Self-alignment ball joint hangers shall be used for rod suspended fixtures, and ceiling canopies shall be fitted tightly to the ceiling without restricting the alignment of several fixtures in a row. Fixtures in suspended ceiling shall be supported with jack chains fasten to the structure.
- .3 Suspension Length
 - .1 The suspension length of all ceiling mounted suspended types of lighting fixtures, as listed in the Fixture Schedule, shall be the overall length from the ceiling to the lowest point of the fixture body, reflector, or glassware in its hanging position.
 - .2 The length of the stems of suspended fluorescent lighting fixtures shall be adjusted to hang all fixture bodies in the same room level and in the same horizontal plane, unless specifically required to be otherwise on the Electrical Drawings.
- .4 Chain Hangers
 - .1 Where fixtures are specified to be chain hung, the chain used shall be No. 4 Tensile bright zinc coated with strength of 181 kg. Attachment shall be made using No. 105 "S" hooks. Wires running down chain to fixture shall be run in flexible conduit and shall be attached to chain with "Plasklip" cable clips.

2.6 **Fixture Construction**

- .1 All interior fixtures shall comply with C.S.A. Standard C22.2, No. 9 latest edition, complete with accessories and components, complying with relevant C.S.A. standards applicable to accessory or components.
- .2 Fixture lens, where specified, shall be flat and in hinged metal frame unless otherwise specified, made from clear pattern acrylic lenses and shall be 100% virgin acrylic.

- .3 Unless otherwise indicated, lighting fixture bodies shall be minimum 20 gauge, cold rolled prime steel of rigid construction with knockout, as required. Fixture rigidity shall permit any suspension method with sag. Fluorescent fixtures shall be suitable for either individual or continuous mounting. Fixture sockets shall apply continuous holding pressure on lamps.
- .4 Fixtures shall be finished in baked white enamel (or other colour if specified or requested by Architect), which shall resist chipping, corrosion and discolouration. Before finishing, all metal shall be chemically degreased and neutralised. Finish shall be not less than two (2) coats of enamel, sprayed on and baked. Reflecting surfaces shall be white with an average reflectance of not less than 85%.
- .5 All fixtures shall be C.S.A. approved and/or approved by the Inspection Department of Ontario Hydro.
- .6 All fixtures types shall be designed with adequate heat sinks to dissipate the generated heat in order to prevent ballast and lamps from overheating with the resulting decrease in their rated life expectancy and/or light output.
- .7 Fixtures shall be designed so that a minimum task required for lamp or ballast replacement.
- .8 Recessed fixtures mounted in an insulated ceiling cavity shall be suitable for such installation. Prior to ordering fixtures confirm on site as to type and placement of insulation relative to fixtures. Where insulation is to be placed over and around fixture, the fixture shall be supplied with CSA listed housing for such installation.

PART 3 - EXECUTION

3.1 Installation

- .1 Installation of all lighting equipment shall comply with the relevant Sections of this specification and the Ontario Hydro Electrical Safety Code.
- .2 Recessed or semi-recessed fixtures shall be wired with BX90 or R90 wire in flexible steel conduit to adjacent outlet boxes placed above the finished ceiling, within reach of the fixture holes. Check the ceiling construction prior to ordering the fixtures to ensure that the fixture mounting is suitable and acceptable to the Engineer.
- .3 Recessed or semi-recessed or surface mounted fixtures shall be supported by chain hangers fastened securely to the structural ceiling; not supported by the tees of the dropped ceiling.
- .4 Plaster frames and rings shall be provided for fixtures recessed in plaster ceilings under this Section. The installation of plaster rings shall be done by others (Division 9) under the supervision of this Contractor to ensure that they are located correctly. All costs for installation by Division 16.
- .5 All outlet boxes for ceiling mounted lighting fixtures are to be flush mounted unless otherwise noted. Where outlet boxes for lighting fixtures are specified to be surface mounted in finished areas on precast ceilings or on existing ceilings, use deep canopies to cover outlet box. In finished areas, canopies are to be neatly notched to provide entry of wiring.
- .6 At the completion of construction and acceptance of work, all lighting fixtures shall be clean, complete with all necessary accessories and provided with the required operating lamp(s).

- .7 Fixtures shown in continuous rows or broken lines shall be carefully aligned so that all rows appear as straight lines. Crooked lines or misplaced fixtures will not be accepted and such poor workmanship shall be corrected.
- .8 Fixtures as shown on the Electrical Drawings are approximate locations only. These drawings are for preparation of tenders only. Installation of fixtures shall be in accordance with reflected ceiling plans, details and/or field instructions issued by the Engineer or Architect.
- .9 Lighting fixtures in the parking garage to be installed such that the lens is below the support beam members in order to cast light over floor areas and vehicles.
- .10 Lighting fixtures in service areas and Mechanical and Electrical Rooms shall be installed after the mechanical and electrical equipment is in place. The fixtures shall be located on site to clear all obstructions and suspended on chain hangers. Rigid mount in air plenum rooms to the approval of the Engineer.
- .11 Check the latest ceiling finishes in all areas where recessed fixtures are being installed to ensure that the fixtures which are ordered for these areas are purchased with suitable ceiling trim for the particular ceiling finish. Fixtures which are sent to the site with incorrect ceiling trim or flanges shall be replaced with fixtures having the correct trims, without additional cost.

PART 1 - GENERAL

1. **OVERVIEW**

- .1 Commissioning is a systematic process of ensuring that all building systems perform interactively according to the design intent and the owner's operational needs. This is achieved by beginning in the design phase and documenting design intent and continuing through construction, acceptance and the warranty period with actual verification of performance. The commissioning process shall encompass and coordinate the traditionally separate functions of system documentation, equipment startup, control system calibration, testing and balancing, performance testing and training.
- .2 The commissioning process does not take away from or reduce the responsibility of the system designers or installing contractors to provide a finished and fully functioning product.
- .3 These commissioning requirements are LEED-focused and are in addition to, not in place of, any additional commissioning requirements located in the electrical, mechanical, or other specifications.

2. **OBJECTIVES**

- .1 Verify that applicable equipment and systems are installed according to the manufacturer's recommendations.
- .2 Verify and document proper performance of equipment and systems.
- .3 Verify that O&M documentation left on site is complete.
- .4 . Verify that the Owner's operating personnel are adequately trained.
- .5 The commissioning process shall meet the requirements of LEED Canada-NC Version 1.0 Prerequisite EAp1, Fundamental Building Systems Commissioning. The commissioning shall also meet the requirements as specified in the technical sections of this specification.

3. **ABBREVIATIONS**

- .1 The following are common abbreviations used in the Specifications and in the Commissioning Plan:

BOD: Basis of Design

CA: Commissioning Authority

Cx: Commissioning

Cx Plan: Commissioning Plan

GC: General contractor

OPR: Owner's Project Requirements

TAB: Testing and Balancing Contractor

4. COMMISSIONING TEAM

- .1 The members of the commissioning team consist of the following:
 - (a) Commissioning authority (CA)
 - (b) General Contractor (GC or Contractor)
 - (c) The architect and design engineers
 - (d) Mechanical Contractor (MC), the Electrical Contractor (EC), the TAB representative, the Controls Contractor (CC)
 - (e) Any other installing subcontractors or suppliers of equipment. If known, the Owner's building or plant operator/engineer is also a member of the commissioning team.

5. SCHEDULING

- .1 The CA will work with the CM and GC according to established protocols to schedule the commissioning activities. The CA will provide sufficient notice to the CM and GC for scheduling commissioning activities. The GC will integrate all commissioning activities into the master schedule. All parties will address scheduling problems and make necessary notifications in a timely manner in order to expedite the commissioning process.
- .2 The CA will provide the initial schedule of primary commissioning events at the commissioning scoping meeting. The Commissioning Plan—Construction Phase provides a format for this schedule. As construction progresses more detailed schedules are developed by the CA. The Commissioning Plan also provides a format for detailed schedules.

6. COMMISSIONING PROCESS

- .1 Commissioning Plan. The commissioning plan provides guidance in the execution of the commissioning process. Just after the initial commissioning scoping meeting the CA will update the plan which is then considered the "final" plan, though it will continue to evolve and expand as the project progresses. The Specifications will take precedence over the Commissioning Plan.
- .2 Commissioning during construction begins with a scoping meeting conducted by the CA where the commissioning process is reviewed with the commissioning team members.
- .3 Additional meetings will be required throughout construction, scheduled by the CA with necessary parties attending, to plan, scope, coordinate, schedule future activities and resolve problems.
- .4 Equipment documentation is submitted to the CA during normal submittals, including detailed start-up procedures.
- .5 The CA works with the Subs in developing startup plans and startup documentation formats, including providing the Subs with prefunctional checklists to be completed, during the startup process.
- .6 In general, the checkout and performance verification proceeds from simple to complex; from component level to equipment to systems and intersystem levels with prefunctional checklists being completed before functional testing.

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- .7 The Subs, under their own direction, execute and document the prefunctional checklists and perform startup and initial checkout. The CA documents that the checklists and startup were completed according to the approved plans. This may include the CA witnessing start-up of selected equipment.
 - .8 The CA develops specific equipment and system functional performance test procedures. The Subs review the procedures.
 - .9 The procedures are executed by the Subs, under the direction of, and documented by the CA.
 - .10 Items of non-compliance in material, installation or setup are corrected at the Sub's expense and the system retested.
 - .11 . The CA reviews the O&M documentation for completeness.
 - .12 The CA reviews, pre-approves and coordinates the training provided by the Subs and verifies that it was completed.
 - .13 Deferred testing is conducted, as specified or required.

7. SYSTEMS TO BE COMMISSIONED

- .1 Fundamental Building Systems Commissioning is limited to those systems and equipment that are central to the Owner's LEED requirements and sustainability goals. LEED commissioning focuses on energy and water-consuming systems. The following systems are included as part of fundamental building systems commissioning requirements.
- .2 Systems included in LEED Commissioning:
 - (a) HVAC systems & controls
 - (b) Interior lighting fixtures & controls
 - (c) Plumbing fixtures & systems
 - (d) Plumbing infrastructure
 - (e) Exterior lighting systems & controls
 - (f) Irrigation
 - (g) Renewable energy systems
- .3 Systems not included in LEED Commissioning:
 - (a) Envelope integrity
 - (b) Fire safety systems
 - (c) Data & Communications
 - (d) Security Systems
 - (e) Alternate Fueling Stations

- (f) Elevators
- (g) Emergency generators & UPS systems

PART 2 - PRODUCTS

1. TEST EQUIPMENT

- .1 All standard testing equipment required to perform startup and initial checkout and required functional performance testing shall be provided by the Division contractor for the equipment being tested. For example, the mechanical contractor of Division 15 shall ultimately be responsible for all standard testing equipment for the HVAC system and controls system in Division 15, except for equipment specific to and used by TAB in their commissioning responsibilities.
- .2 Special equipment, tools and instruments (only available from vendor, specific to a piece of equipment) required for testing equipment, according to these Contract Documents shall be included in the base bid price to the Contractor and left on site, except for stand-alone datalogging equipment that may be used by the CA.
- .3 All testing equipment shall be of sufficient quality and accuracy to test and/or measure system performance with the tolerances specified in the Specifications. If not otherwise noted, the following minimum requirements apply: Temperature sensors and digital thermometers shall have a certified calibration within the past year to accuracy of 0.5°F and a resolution of + or - 0.1°F. Pressure sensors shall have an accuracy of + or - 2.0% of the value range being measured (not full range of meter) and have been calibrated within the last year. All equipment shall be calibrated according to the manufacturer's recommended intervals and when dropped or damaged. Calibration tags shall be affixed or certificates readily available.

PART 3 - EXECUTION

1. MEETINGS

- .1 Scoping Meeting. The CA will schedule, plan and conduct a commissioning scoping meeting with the entire commissioning team in attendance. Meeting minutes will be distributed to all parties by the CA. Information gathered from this meeting will allow the CA to revise the Commissioning Plan to its "final" version, which will also be distributed to all parties.
- .2 Miscellaneous Meetings. Other meetings will be planned and conducted by the CA as construction progresses. These meetings will cover coordination, deficiency resolution and planning issues with particular Subs. The CA will plan these meetings and will minimize unnecessary time being spent by Subs.

2. REPORTING

- .1 The CA will provide regular reports to the Owner and project manager with increasing frequency as construction and commissioning progresses. Standard forms are provided and referenced in the Commissioning Plan.

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- .2 The CA will regularly communicate with all members of the commissioning team, keeping them apprised of commissioning progress and scheduling changes through memos, progress reports, etc.
 - .3 Testing or review approvals and non-conformance and deficiency reports are made regularly with the review and testing as described in later sections.
 - .4 A final summary report (about four to six pages, not including backup documentation) by the CA will be provided to the CM or PM, focusing on evaluating commissioning process issues and identifying areas where the process could be improved. All acquired documentation, logs, minutes, reports, deficiency lists, communications, findings, unresolved issues, etc., will be compiled in appendices and provided with the summary report. Prefunctional checklists, functional tests and monitoring reports will not be part of the final report, but will be stored in the Commissioning Record in the O&M manuals.

3. SUBMITTALS

- .1 In general, the following submittals are required to be submitted to the CA throughout construction. The specific submittal list appears in the Cx Plan.
 - (a) Shop drawings, including full sequences of operation and O&M data, to be approved by the CA during the standard engineer's shop drawing review process
 - (b) Control drawings for all commissioned equipment
 - (c) Completed installation / pre-verification checklist
 - (d) Completed functional performance checklist
 - (e) Air and Water Balancing report
 - (f) Complete set of O&M manuals, in **PDF** format and hardcopy
 - (g) Training checklists
 - (h) **DVDs** indicating videotaped training session for all systems.
- .2 At minimum, the request will include the manufacturer and model number, the manufacturer's printed installation and detailed start-up procedures, full sequences of operation, O&M data, performance data, any performance test procedures, control drawings and details of owner contracted tests. In addition, the installation and checkout materials that are actually shipped inside the equipment and the actual field checkout sheet forms to be used by the factory or field technicians shall be submitted to the Commissioning authority. All documentation requested by the CA will be included by the Subs in their O&M manual contributions.
- .3 The Commissioning authority will review and approve submittals related to the commissioned equipment for conformance to the Contract Documents as it relates to the commissioning process, to the functional performance of the equipment and adequacy for developing test procedures. This review is intended primarily to aid in the development of functional testing procedures and only secondarily to verify compliance with equipment specifications. The Commissioning authority will notify the CM, PM or A/E as requested, of items missing or areas that are not in conformance with Contract Documents and which requires resubmission.

- .4 These submittals to the CA do not constitute compliance for O&M manual documentation. The O&M manuals are the responsibility of the Contractor, though the CA will review and approve them.

4. START-UP, PREFUNCTIONAL CHECKLISTS AND INITIAL CHECKOUT

- .1 General. Prefunctional checklists are important to ensure that the equipment and systems are hooked up and operational. It ensures that functional performance testing (in-depth system checkout) may proceed without unnecessary delays. Each piece of equipment receives full prefunctional checkout. No sampling strategies are used. The prefunctional testing for a given system must be successfully completed prior to formal functional performance testing of equipment or subsystems of the given system.
- .2 Start-up and Initial Checkout Plan. The CA shall assist the commissioning team members responsible for startup of any equipment in developing detailed start-up plans for all equipment. The primary role of the CA in this process is to ensure that there is written documentation that each of the manufacturer-recommended procedures have been completed. Parties responsible for prefunctional checklists and startup are identified in the commissioning scoping meeting and in the checklist forms.
- .3 The CA adapts, if necessary, the representative prefunctional checklists and procedures. These checklists indicate required procedures to be executed as part of startup and initial checkout of the systems and the party responsible for their execution.
- .4 These checklists and tests are provided by the CA to the Contractor. The Contractor determines which trade is responsible for executing and documenting each of the line item tasks and notes that trade on the form. Each form will have more than one trade responsible for its execution.
- .5 The subcontractor responsible for the purchase of the equipment develops the full start-up plan by combining (or adding to) the CA's checklists with the manufacturer's detailed start-up and checkout procedures from the O&M manual and the normally used field checkout sheets. The plan will include checklists and procedures with specific boxes or lines for recording and documenting the checking and inspections of each procedure and a summary statement with a signature block at the end of the plan.
- .6 The subcontractor submits the full startup plan to the CA for review and approval.
- .7 The CA reviews and approves the procedures and the format for documenting them, noting any procedures that need to be added.
- .8 The full start-up procedures and the approval form may be provided to the CM for review and approval, depending on management protocol.
- .9 Execution of Prefunctional Checklists and Startup.
- .10 Four weeks prior to startup, the Subs and vendors schedule startup and checkout with the CM, GC and CA. The performance of the prefunctional checklists, startup and checkout are directed and executed by the Sub or vendor. When checking off prefunctional checklists, signatures may be required of other Subs for verification of completion of their work.
- .11 The CA shall observe, at minimum, the procedures for each piece of primary equipment, unless there are multiple units, (in which case a sampling strategy may be used as approved by the CM). In no case will the number of units witnessed be less than four on any one building, nor less than 20% of the total number of identical or very similar units.

- .12 For lower-level components of equipment, (e.g., VAV boxes, sensors, controllers), the CA shall observe a sampling of the prefunctional and start-up procedures. The sampling procedures are identified in the commissioning plan.
- .13 The Subs and vendors shall execute startup and provide the CA with a signed and dated copy of the completed start-up and prefunctional tests and checklists.
- .14 Only individuals that have direct knowledge and witnessed that a line item task on the prefunctional checklist was actually performed shall initial or check that item off. It is not acceptable for witnessing supervisors to fill out these forms.

5. FUNCTIONAL PERFORMANCE TESTING

- .1 This sub-section applies to all commissioning functional testing for all divisions.
- .2 Objectives and Scope. The objective of functional performance testing is to demonstrate that each system is operating according to the documented design intent and Contract Documents. Functional testing facilitates bringing the systems from a state of substantial completion to full dynamic operation. Additionally, during the testing process, areas of deficient performance are identified and corrected, improving the operation and functioning of the systems.
- .3 In general, each system should be operated through all modes of operation (seasonal, occupied, unoccupied, warm-up, cool-down, part- and full-load) where there is a specified system response. Verifying each sequence in the sequences of operation is required. Proper responses to such modes and conditions as power failure, freeze condition, low oil pressure, no flow, equipment failure, etc. shall also be tested.
- .4 Development of Test Procedures. Before test procedures are written, the CA shall obtain all requested documentation and a current list of change orders affecting equipment or systems, including an updated points list, program code, control sequences and parameters. The CA shall develop specific test procedures and forms to verify and document proper operation of each piece of equipment and system. Each Sub or vendor responsible to execute a test, shall provide limited assistance to the CA in developing the procedures review (answering questions about equipment, operation, sequences, etc.). Prior to execution, the CA shall provide a copy of the test procedures to the Sub(s) who shall review the tests for feasibility, safety, equipment and warranty protection.
- .5 The CA shall review owner-contracted, factory testing or required owner acceptance tests which the CA is not responsible to oversee, including documentation format, and shall determine what further testing or format changes may be required to comply with the Specifications. Redundancy of testing shall be minimized.
- .6 The purpose of any given specific test is to verify and document compliance with the stated criteria of acceptance given on the test form.
- .7 Coordination and Scheduling. The Subs shall provide sufficient notice to the CA regarding their completion schedule for the prefunctional checklists and startup of all equipment and systems. The CA will schedule functional tests through the CM, GC and affected Subs. The CA shall direct, witness and document the functional testing of all equipment and systems. The Subs shall execute the tests.
- .8 In general, functional testing is conducted after prefunctional testing and startup has been satisfactorily completed. The control system is sufficiently tested and approved by the CA before it is used for TAB or to verify performance of other components or systems. The air

balancing and water balancing is completed and debugged before functional testing of air-related or water-related equipment or systems. Testing proceeds from components to subsystems to systems. When the proper performance of all interacting individual systems has been achieved, the interface or coordinated responses between systems is checked.

6. DOCUMENTATION, NON-CONFORMANCE AND APPROVAL OF TESTS

- .1 Documentation. The CA shall witness and document the results of all functional performance tests using the specific procedural forms developed for that purpose. Prior to testing, these forms are provided to the CM for review and approval and to the Subs for review. The CA will include the filled out forms in the O&M manuals.
- .2 The CA will record the results of the functional test on the procedure or test form. All deficiencies or non-conformance issues shall be noted and reported to the CM on a standard non-compliance form.
- .3 Corrections of minor deficiencies identified may be made during the tests at the discretion of the CA. In such cases the deficiency and resolution will be documented on the procedure form.

7. OPERATION AND MAINTENANCE MANUALS

- .1 The specific content and format requirements for the standard O&M manuals are provided in Divisions 15 and 16.
- .2 In addition to standard O&M manuals, all Subs are required to submit all shop drawings in electronic format (PDF). The pdf files must be reasonably sized (less than 5 MB per file) and named and categorized on CD and/or FTP site.
- .3 This work does not supersede the A/E's review of the O&M manuals according to the A/E's contract.

8. TRAINING OF OWNER PERSONNEL / PROPERTY MANAGEMENT / MAINTENANCE CONTRACTORS

- .1 The GC shall be responsible for training coordination and scheduling and ultimately for ensuring that training is completed.
- .2 The CA shall be responsible for overseeing and approving the content and adequacy of the training of Owner personnel for commissioned equipment.
- .3 All training sessions are to videotaped as arranged by the GC.
- .4 In addition to these general requirements, the specific training requirements of Owner personnel by Subs and vendors are specified in Division 15 and 16.
- .5 Each Sub and vendor responsible for training will submit a written training plan to the CA for review and approval prior to training. The plan will cover the following elements:
 - (a) Equipment (included in training)
 - (b) Intended audience
 - (c) Location of training
 - (d) Objectives

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- (e) Subjects covered (description, duration of discussion, special methods, etc.)
 - (f) Duration of training on each subject
 - (g) Instructor for each subject
 - (h) Methods (classroom lecture, video, site walk-through, actual operational demonstrations, written handouts, etc.)
 - (i) Instructor and qualifications
- .6 For the primary HVAC equipment, the Controls Contractor shall provide a short discussion of the control of the equipment during the mechanical or electrical training conducted by others.
 - .7 The CA develops an overall training plan and coordinates and schedules, with the CM and GC, the overall training for the commissioned systems. The CA develops criteria for determining that the training was satisfactorily completed, including attending some of the training, etc. The CA recommends approval of the training to the CM using a standard form. The CM also signs the approval form.
 - .8 The mechanical design engineer shall at the first training session present the overall system design concept and the design concept of each equipment section.
9. DEFERRED TESTING
- .1 Unforeseen Deferred Tests. If any check or test cannot be completed due to the building structure, required occupancy condition or other deficiency, execution of checklists and functional testing may be delayed upon approval of the PM. These tests will be conducted in the same manner as the seasonal tests as soon as possible. Services of necessary parties will be negotiated.
 - .2 Seasonal Testing. During the warranty period, seasonal testing (tests delayed until weather conditions are closer to the system's design) shall be completed as part of this contract. The CA shall coordinate this activity. Tests will be executed, documented and deficiencies corrected by the appropriate Subs, with facilities staff and the CA witnessing. Any final adjustments to the O&M manuals and as-builds due to the testing will be made.
10. POST-OCCUPANCY REVIEW
- .1 All subs must return to the site 10 months after substantial completion to participate in a walk-through conducted by the CA and property manager.
 - .2 The walk-through will address outstanding deficiencies, warranty issues, clean-up and project close-out.