

LIST OF SECTIONS – ELECTRICAL, COMMUNICATIONS, AND SECURITY
26 00 01

DIVISION 26 – ELECTRICAL

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END OF SECTION

ELECTRICAL GENERAL REQUIREMENTS

26 01 01

1 GENERAL

1.1 General Contract Documents

- .1 Comply with General Conditions of the Contract, Supplementary Conditions of the Contract and Division 01 - General Requirements.
- .2 Where content in this Specification section duplicates requirements in various Division 01 Specification sections, this section and the applicable Division 01 sections are to be read together and the most stringent requirements apply.

1.2 Work Included

- .1 Work to be done under Divisions 26, 27 and 28 to include furnishing of labour, materials, equipment and services required for installation, testing and putting into proper operation complete electrical systems as shown, as specified, as intended, and as otherwise required. Complete systems to be left ready for continuous and efficient satisfactory operation.
- .2 Read drawings and specifications together as a whole and in conjunction with other such documents included under the Construction Contract.

1.3 Document Organization

- .1 Applicable Divisions for Electrical Work:
 - .1 Division 26 - Electrical
 - .2 Division 27 - Communications
 - .3 Division 28 - Electronic Safety and Security
- .2 For clarity, any reference in the Contract Documents to Division 26 includes Division 27 and 28.
- .3 The Specifications for these Divisions are arranged in Sections for convenience. It is not intended to recognize, set or define limits to any subcontract or to restrict Contractor in letting subcontracts.
- .4 Contractor is responsible for completion of the Work whether or not portions are sublet.

1.4 Division 26, as it Applies to Division 27 and 28

- .1 Division 26 contains common work requirements that are applicable as necessary to the Work of Divisions 27 and 28 and apply as if written in full within those Divisions.

1.5 Language

- .1 Specifications are written as a series of instructions addressed to the Contractor, and by implication to subcontractors and to suppliers. For clarity and brevity, use is made of numbered lists and bulleted lists. Where the list follows a semi-colon (;) punctuation is for clarity, where the list follows a colon (:) punctuation is to be read as short-hand form of verb "to be" or "to have" as context requires.
- .2 It is not intended to debate with the Contractor reasons for these instructions, and words associated with justification for an instruction or restatement of anticipated performance have been omitted to avoid possible ambiguities.

1.6 Definitions and Abbreviations

- .1 Other specification sections of Divisions 26 to 28 of the Work may also include additional specific definitions and/or abbreviations that apply to that specification section.
- .2 The following terms apply to Divisions 26 to 28 of the Work:

- .1 The words "indicated", "shown", "noted", "listed" or similar words or phrases used in these Specifications, mean that the material or item referred to is "indicated", "shown", "listed" or "noted" on the Drawings or in the Specifications.
 - .2 Wherever the word "listed" is used in conjunction with a product and a product certification standard (including but not limited to CSA, ULC, CGSB, BNQ, UL), it shall be understood to mean that the product is "listed" by an accredited 3rd party testing laboratory as being certified to the referenced product standard.
 - .3 Wherever the words "approved", or similar words or phrases are used in the Specification they shall be understood, unless the context otherwise provides to mean that material or item referred to shall be "approved by" the Owner.
 - .4 Wherever the words "satisfactory", "as directed", "submit", "permitted", "reviewed", or similar words or phrases are used in the Specification they shall be understood, unless the context otherwise provides to mean that material or item referred to shall be "satisfactory to", "as directed by", "submitted to", "permitted by", or "reviewed by" the Consultant.
 - .5 Instructions using any form of the word:
 - (a) "install" means to place in position for service or use.
 - (b) "supply" means to procure and deliver materials, or to make available labour or services for the stated purpose.
 - (c) "provide" means to supply material, labour and services to install the referenced item.
 - .6 The term "building code" means the edition of the applicable building code at the location of the Work at the time of obtaining a building permit.
 - .7 The terms "electrical code" and "electrical safety code" mean the edition of the applicable electrical safety code adopted by regulation at the location of the Work at the time of obtaining an electrical works permit.
 - .8 The term "AHJ" and "local authority" means the "Authority Having Jurisdiction" and can include the local building inspector, the local fire department and the electrical safety inspector or their agents.
 - .9 Wherever manufacturers or manufacturer's products are identified in lists under the phrase "Standard of Acceptance", these are manufacturers and/or products which meet the project standards in regard to performance, quality of material and workmanship.
- .3 The following abbreviations apply to this specification section:
- .1 NECA – National Electrical Contractors Association

1.7 Examination

- .1 Examine any existing buildings and services, local conditions, building site, Specifications, and Drawings and report any condition, defect or interference that would prevent execution of the Work.
- .2 No allowance will be made for any expense incurred through failure to make these examinations of the site and documents prior to Tender or on account of any conditions on site or any growth or item existing there which was visible or known to exist at time of Tender.
- .3 Before commencing work under this Division, examine the work of other Divisions of the Work and report any defect or interference.

1.8 Design Services

- .1 Provide specialty design services for elements of the Work where specified in other sections of Division 26. Drawing and specifications prepared by such specialty design service providers shall be sealed by a professional engineer licensed in the jurisdiction of the Work.

1.9 Product Substitutions

- .1 Comply with Specification section 01 25 00 *Substitution Procedures* for requests for substitution of products.

2 SHIPPING, HANDLING AND STORAGE

2.1 Shipping

- .1 Provide adequate protection of equipment during shipping and handling to provide equipment at the site in ex-works condition when handled by commercial carrier systems.
- .2 Each drawout element such as high voltage circuit breakers, power circuit breakers, transfer switch modules, etc. to be packaged separately from its associated enclosure.
- .3 Provide as necessary, removable bracing of the internal components in each item of equipment so that the equipment can be moved on its side or back, without sustaining damage.
- .4 Where removeable internal bracing has been provided, the equipment to be provided with warning labels to call for the removal of the shipping bracing prior to energization.
- .5 Any component packaged or shipped separately to be individually crated and tagged with unit number and the equipment number of the assembly to which it belongs.
- .6 Provide each "shipping section" with a permanently-attached, readily-visible identification tag bearing the equipment number of the assembly of which it is a part.

2.2 Storage

- .1 Store equipment and materials at the worksite to protect them from any damage until placed into its final location. Maintain similar protection of installed equipment and materials to protect against damage until they are turned over to the Owner. Make good any damage to equipment or materials up to the time of Ready-for-Takeover.
- .2 Store electrical materials and equipment such as switchboards, panels, transformers, bus ducts, fire alarm devices, luminaires, etc., in a dry, clean location and cover with polyethylene plastic to preserve factory finish.
- .3 Protect exposed or free standing equipment with plastic to minimize entry of dust and dirt and marring of finished surfaces during progress of work.
- .4 Schedule luminaires, lamps, diffusers and fire detectors for installation as late as possible during construction in order to minimize accumulation of dust and/or dirt on them. Clean luminaires and diffusers, not acceptable because of dust and dirt, in an approved manner in accordance with the manufacturer's instructions. Wrap surface mounted and suspended luminaires and fire detectors, installed prior to painting or dusty construction being completed in the area, in plastic to prevent dirt or paint from settling on them.
- .5 Wrap bus ducts in heavy gauge plastic to adequately prevent moisture and dirt from entering bus duct. Wrapping to remain until bus ducts are ready to be energized.
- .6 Provide adequate ventilation and temporary heating to prevent condensation of moisture within the enclosed equipment.

2.3 Provisions for Handling and Field Erection

- .1 For equipment that will require hoisting on site, provide removable side panels, lifting angles or lifting plates to accommodate the use of slings or crane hooks, for each shipping section.
- .2 For floor mounted equipment, provide on each shipping section, removable steel channel base plates to permit use of pipe rollers or dollies without damaging the equipment.

3 OWNER'S SPECIAL REQUIREMENTS FOR EXISTING SITES

- .1 The following special requirements are in addition to the requirements of Division 01 of the Work.
- .2 Provide a written list of names of employees and sub-trades employees entering the building, advising which areas they need access to at least 48 hours prior to expected time of arrival. This lead time is required to prearrange security passes.
- .3 Security passes to be visibly worn at all times by all employees.
- .4 Trades people to strictly adhere to Owner's building security procedures otherwise entrance into the building will be denied.
- .5 Trades people are to enter via the entrance identified by the Owner.
- .6 Park vehicles in designated areas. Do not block driveways.
- .7 Use only the freight elevator to transport tools and material. Freight elevator door to be shut immediately after exiting the cab.
- .8 Do not disable or activate any electrical or mechanical system without prior approval by the Owner's Project Manager. Also, prior to disabling or activation of any electrical or mechanical system, obtain approval from Building Operations and Building Security.
- .9 Submit prior notification to Building Security Staff before any construction activity commences which will result in heat, smoke, dust or fumes, such as welding, saw cutting, soldering, spray painting, which might affect sensitive fire detection and protection equipment.
- .10 Submit notifications sufficiently in advance such that the Owner will have at least 48 hours to make the necessary arrangements should Building Operations deem that work on a particular system requires a security escort. A security escort will be required for any work being done in secured areas, e.g. raised floor, computer room and mechanical/electrical rooms.
- .11 Provide at least 48 hours prior notification to Building Operations for any fire system isolation requests.
- .12 Schedule work and meet with sub-trades daily on site, to show trades people the work areas and work to be done.
- .13 Trades-people are to supply and use their own tools. No tools, ladders or equipment, etc. will be loaned by the Owner.
- .14 Provide environmental cleaning of the job site daily during construction and upon completion. This includes both under raised floor and above ceiling. Do not store materials or garbage on the loading dock.
- .15 Provide special care, attention and protection when transporting equipment and materials to prevent accidental damage to fire protection equipment, finishes, furnishings and fixtures.
- .16 "No Smoking" – this is a smoke-free building. Violators will be asked to leave and may be denied reentry. Smoking is not allowed on the roof.
- .17 A security escort will be required for any work being done in secured areas, e.g. raised floor, computer room and mechanical/electrical rooms.
- .18 If Building Operations deems that work on a particular system requires security escort, allow 48 hours to make appropriate arrangements.
- .19 For any open flame work, a fire extinguisher and security fire watch is required, and will be provided and paid for by the Owner. Provide 48 hours prior notice to allow the Owner to make the necessary arrangements.
- .20 Obtain the approval of the Building Manager for the storage of materials on site.
- .21 Perform a daily cleanup prior to leaving the site.

- .22 Secure oxygen and acetylene cylinders at all times and capped nightly.
- .23 Restore operating and redundant systems to their normal condition at the end of each work day.
- .24 At the conclusion of each work day, the Contractor's superintendent/supervisor is to advise the Building Manager on the day's activities and plans for the next day's work.

4 PROGRESS PAYMENT PROCEDURE

4.1 Schedule of Values

- .1 Comply with Specification section 01 29 00 *Payment Procedures*.
- .2 For each SOV, include a line item "Interference & Coordination Drawings" and include a value that is the greater of:
 - .1 the value of the work or,
 - .2 1% of the Division 26 contract price.

Payment of the indicated amount will not be made until satisfactory evidence of completion of this work element has been received by the Consultant. Where satisfactory documents are not received, a Change Order will be issued to delete this work element and the amount from the Contract Price.

- .3 For each SOV, include a line item "As-Builts & Operating Manuals" and includes a value that is the greater of:
 - .1 the value of the work or,
 - .2 1% of the Division 26 contract price.

Payment of the indicated amount will not be made until satisfactory documents have been received by the Consultant. Where satisfactory documents are not received, a Change Directive will be issued to delete this work element and the amount from the Contract Price.

5 CONSTRUCTION CHANGES

5.1 General

- .1 Comply with Specification section 01 26 00 *Contract Modifications*.

5.2 Definitions

- .1 The following definitions apply to this section
 - .1 **RS Means manual** – the trade pricing reference book published by Cordin Group Inc. that is applicable to the jurisdiction of the project.
 - .1 **Base wage rate** – the hourly rate actually paid to the trades person, determined in accordance with applicable collective bargaining agreement, or in their absence the actual gross wages paid to the worker.
 - .2 **NECA manual** – the trade pricing reference book published by the National Electrical Contractors Association.

6 SUBMITTALS

6.1 Shop Drawings and Product Data

- .1 Submit shop drawings, manufacturers and product data and samples in accordance with the requirements of Specification sections of Division 01, this Part, and as further required in other specification Sections of Division 26.

- .2 Submit for each item of equipment.
- .3 Submit shop drawings in the same unit of measure as used on the drawings. Both metric and U.S. customary measures may be included.
- .4 Submit shop drawings by email to: shopdrawings@hhangus.com , except where a project document management web-service is used.
- .5 Include an H.H. Angus shop drawing cover sheet form prepared for this project, for each shop drawing submittal (refer to part "Attachment" for an example of this form), or, include the same information on the contractors submittal cover sheet:
 - .1 Provide the following information on each submission;
 - (a) Client/Architect name,
 - (b) Project Name,
 - (c) H.H. Angus project number,
 - (d) Date,
 - (e) Contractor name,
 - (f) Contractor reference No.,
 - (g) Manufacturer name,
 - (h) Product type,
 - (i) Specification section number,
 - (j) Contractor trade category: architectural, structural, conveying equipment, user equipment, mechanical, electrical, telecommunications, civil or other.
 - (k) If a re-submission, the Consultant's previous submittal reference number.
- .6 Submit shop drawings in PDF format except as follows;
 - .1 if the Consultant agrees to a shop drawing to be submitted in hardcopy format, submit in 11 x 17, black and white originals of graphic quality suitable for photocopying and digital scanning. Allow one additional week for processing of shop drawings submitted in hardcopy format.
- .7 Manufacturers' printed product data sheets for standard items are acceptable in place of shop drawings provided that physical characteristics are identified and are related to specification references.
- .8 Submit manufacturers' data sheets with typed schedules listing manufacturers' and suppliers' name and catalogue model numbers for such items as fire alarm system components, etc.
- .9 For luminaires, submit bound sets of luminaire fixture sheets with manufacturers' names and catalogue numbers for all luminaires to be used on the project. Identify and arrange the luminaire fixture sheets and catalogue numbers in the same sequence as the Specification Luminaire List.
- .10 Shop drawings and/or product data sheets to show;
 - .1 CSA or equivalent approval,
 - .2 dimensioned outlines of equipment and construction details,
 - .3 equipment weights and center of gravity,
 - .4 performance ratings,
 - .5 dimensioned details showing service connection points,
 - .6 general routing of bus ducts and connecting services,
 - .7 mounting and fixing arrangements,
 - .8 operating and maintenance clearances,
 - .9 access door swing spaces,

- .11 Where applicable, include;
 - .1 wiring, single line and schematic diagrams,
 - .2 diagrams showing interconnection with work of other Sections,
 - .3 elevations illustrating locations of visible equipment such as pilot lights, breakers and their trip settings, windows, meters, and access doors,
 - .4 component assemblies,
 - .5 trip settings,
 - .6 description of operation.
- .12 Check and stamp each shop drawing as being correct before submission. Shop drawings without such stamps will be rejected and returned.
- .13 Keep one copy of each reviewed shop drawing and product data sheet on site and have them available for reference purposes.
- .14 Where equipment is delivered without reviewed shop drawings, equipment will be condemned and is to be removed from site and replaced with new equipment after shop drawings have been submitted and reviewed.

6.2 Coordination, Fabrication, or Installation Drawings

- .1 Contractor's coordination, fabrication, installation, and/or sleeving drawings will not be reviewed as shop drawings. If submitted as a shop drawing, a transmittal will be returned identifying that the submitted drawings have not been reviewed as a shop drawing.
- .2 Maintain a copy on site of such drawings for reference by the Consultant.
- .3 The Consultant reserves the right to request selected Contractor's coordination, fabrication, or installation drawings for review.

6.3 Effect of Consultants Review of Submittals

- .1 Consultant's review of shop drawings is performed on a sampling basis only, to confirm to Consultant's satisfaction that the Contractor understands the Work to be performed and is interpreting the design documents correctly, and such reviews are performed for the benefit of the Owner.
- .2 For greater certainty, the review of shop drawings by Consultant does not constitute a quality control function for the benefit of Contractor, nor does such a review relieve Contractor of their responsibility for complying with the Contract documents.

7 APPLICABLE CODES AND STANDARDS; PERMITS

7.1 Codes, Standards and Regulations

- .1 Where a published product standard or installation code is adopted by statute or regulation by an applicable AHJ, the applicable edition of the standard or code is the one that has been adopted
 - .1 at the time of obtaining a permit for the applicable portion of the Work, or
 - .2 in the absence of a requirement for a permit, the start date of construction.
- .2 Where a published product standard or installation code is not adopted by statute or regulation, then the most current edition of that standard or code at the start date of construction applies.
- .3 Install electrical systems in accordance with the electrical safety code adopted by the AHJ responsible for electrical safety at the location of the Work.
- .4 Install underground systems in accordance with the latest edition of CSA C22.3 No.7 *Underground Systems* except where specified otherwise.

- .5 Comply with CSA Certification Standards and safety bulletins issued by the AHJ for electrical safety applicable to the place of the Work
- .6 Where requirements of this specification exceed those of the above mentioned codes, standards, bulletins, this specification is to govern.
- .7 In the event of a conflict between codes, bulletins, regulations, or standards, or where work shown is in conflict with these documents, obtain interpretation before proceeding. Failure to clarify any ambiguity will result in an interpretation requiring the application of the most demanding requirements.

7.2 Confined Spaces

- .1 Unless otherwise prescribed by the Constructor's/Owner's workplace safety program, treat spaces not designed and constructed for continuous human occupancy as "confined spaces" in accordance with applicable health and safety legislation, including but not limited to;
 - .1 horizontal and vertical service spaces, shafts, and tunnels,
 - .2 inside of equipment which permits entry of the head and/or whole body, and
 - .3 ceiling spaces which are identified as containing a hazardous substance.

7.3 Permits, Fees and Inspections

- .1 Submit to the AHJ for electrical safety the necessary number of drawings and specifications for examination and approval prior to commencement of work.
- .2 Arrange and pay for permits, tests, and Certificates of Inspection required by the AHJ for electrical safety.
- .3 Consultant will provide drawings and specifications required by the AHJ for electrical safety at no cost.
- .4 Notify Consultant of changes required by the AHJ for electrical safety prior to making changes.
- .5 Furnish to Consultant, Certificates of Acceptance from the AHJ for electrical safety upon completion of the Work.

8 COMMON PRODUCT REQUIREMENTS

8.1 Standard of Material and Equipment

- .1 Provide materials and equipment in accordance with This Division.
- .2 Materials and equipment:
 - .1 new and of uniform pattern throughout the Work,
 - .2 of Canadian manufacture where obtainable,
 - .3 standard products of approved manufacture,
 - .4 labelled or listed (certified) to applicable standards in accordance with specification sections of the Work and as required by the AHJ for electrical safety; where there is no alternative to supplying equipment which is not certified, obtain special approval from the AHJ for electrical safety.
 - .5 in compliance with Standards and Regulations with respect to;
 - (a) chemical and physical properties of materials,
 - (b) design,
 - (c) performance characteristics, and
 - (d) methods of construction and installation,
 - .6 identical units of equipment to be of same manufacture within any unit of equipment,

- .7 identical component parts to be of same manufacture, but various component parts comprising the unit need not be from one manufacturer.
- .3 Materials and equipment are described to establish standards of construction and workmanship. Where manufacturers and/or products are listed under "Standard of Acceptance", select manufacturers and or products from these lists. Use of manufacturers or products other than as listed are subject to specification requirements concerning requests for substitution.
- .4 Include items of material and equipment not specifically noted on Drawings or mentioned in Specifications but which are required to make a complete and operating system.
- .5 Confirm capacity or ratings of equipment being provided, when based on ratings of equipment being provided under other trade Sections, before such items are purchased.
- .6 Provide equipment marked for use with 75°C wiring or with a higher temperature rating. If equipment is not marked with a temperature rating or if the only rating available is less than 75°C, increase the associated conductor sizes accordingly, to the satisfaction of the consultant.
- .7 Factory fabricate control panels and component assemblies are to be listed for electrical safety requirements.
- .8 Select materials and equipment in accordance with manufacturer's recommendations and these Specifications, and install in accordance with manufacturer's instructions and these Specifications,
- .9 Materials and equipment not satisfying these selection criteria will be condemned. Remove condemned materials from job site and provide properly selected and approved materials.

8.2 Voltage Ratings

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

8.3 Manufacturers Nameplates

- .1 Provide manufactured equipment with metal nameplate with raised or recessed lettering, mounted on each piece of equipment.
- .2 Manufacturer's nameplate to indicate equipment size, capacity, model designation, manufacturer's name, serial number, voltage, cycle, phase and power rating, and approval listings.
- .3 Certified products are to clearly show the mark of the certification agency when in the final installed state.

8.4 Finishes

- .1 Primary and final painting for Work, other than items specified as factory primed or finished, to be done under Finish Division 9.
- .2 Shop finish metal enclosure surfaces by application of rust resistant primer inside and outside, and at least two coats of finish enamel.
- .3 Touch-up factory painted prime and/or final coats damaged during construction, with colour matching paint recommended by the equipment manufacturer.
- .4 Leave a quart can or a pressurized spray can of paint, as used with switchboards, with Owner for touch-up purposes.
- .5 Clean and prime exposed non-galvanized hangers, racks and fastenings to prevent rusting.

8.5 Provision for Future

- .1 Where space is indicated as reserved for future equipment or for future extension to building, leave such space clear and install piping, raceways and equipment so that connections can be made to future apparatus or building.
- .2 Identify provisions and service terminations for future on Record Drawings.

8.6 Pre-purchased Equipment; Damage and Ownership

- .1 At time of receipt of pre-purchased or pre-tendered equipment at the job site by the installing electrical contractor, provide the services of the manufacturer/distributor/supplier's technical representative to:
 - .1 inspect the equipment prior to unloading,
 - .2 witness the unloading and advise the contractor on the appropriate method for handling the equipment in order to avoid damage during the unloading, moving and setting in place phase of the equipment, and
 - .3 report any damage to the Consultant.
- .2 In the event that the equipment or cable is found to be damaged before unloading it is to be returned immediately to the factory for repairs and/or replacement by the manufacturer/supplier.
- .3 In the event of damage occurring at any time during unloading and until the equipment is accepted by the Owner, the installing contractor is responsible for repairs and/or replacement of the damaged equipment to the satisfaction of the Owner.

9 OFFICE, STORAGE & TOOLS

9.1 Office and Storage

- .1 Provide temporary office and lunchroom facilities, workshop, tools and material storage space. Facilities may be site trailers or as otherwise approved by the General Contractor/Construction Manager.
- .2 Assume responsibility for these facilities.
- .3 Provide power, heat, light, telephone and internet services.
- .4 Owner's cafeteria is off limits.

9.2 Tools, Temporary Equipment and Materials

- .1 Provide tools, equipment, scaffolding, extension cords, lamps and miscellaneous consumable materials, as required to carry out the Work.

10 COORDINATION; INTALLATION DRAWINGS

10.1 Coordination

- .1 Consultant's drawings are diagrammatic and illustrate the general location of equipment, and intended routing of ductbanks, conduits, cable trays, feeders, etc. and do not show every structural detail. In congested areas drawings at greater scale may be provided to improve interpretation of the Work. Where equipment or systems are shown as "double line", they are done so either to improve understanding of the Work, or simply as a result of the use of a CAD drawing tool, and in either case such drawings are not represented as fabrication or installation drawings.
- .2 Lay out and coordinate the Work to avoid conflict with work under other Divisions.
- .3 Make good damage to Owner's property or to other trade's work caused by inaccurate layout or careless performance of the Work.

- .4 Where equipment provided under other Divisions connects with material or equipment supplied under this Division, confirm capacity and ratings of equipment being provided.
- .5 Take information involving accurate measurements from dimensioned Architectural Drawings or at the building.
- .6 Install services and equipment which are to be concealed, close to the building structure so that furring is kept to minimum dimensions.
- .7 Location of conduit, bus duct, raceways and equipment may be altered without extra cost provided instruction is given or approval is obtained, in advance of installation of items involved. Changes will be authorized by site instructions and are to be shown on Record Drawings.
- .8 Include incidental material and equipment not specifically noted on Drawings or mentioned in Specifications but which is needed to complete the Work as an operating installation.

10.2 Field, Fabrication, and Installation Drawings

- .1 Prepare field, fabrication, and/or installation drawings to show location of equipment and relative position of services and to demonstrate coordination with the work of other trades;
 - .1 drawing scale: minimum 1:50 (1/4"=1'-0"),
 - .2 use information from manufacturer's shop drawings for each trade and figured dimensions from latest Architectural and Structural Drawings,
 - .3 layout equipment and services to provide access for repair and maintenance,
- .2 Circulate drawings to other trades involved in each area, and conduct coordination meetings with those trades.

11 ANCHORS AND INSERTS

- .1 Supply anchor bolts and locating templates for installation in advance of concrete pouring.

12 CUTTING AND REMEDIAL WORK

12.1 General

- .1 Assume responsibility for prompt installation of work in advance of concrete pouring, masonry, roofing, finishing and similar work. Should any cutting or repairing of either unfinished or finished work be required because such installation was not done, employ the particular trade, whose work is involved, to do such cutting and patching and pay for any resulting costs.
- .2 Neatly cut or drill holes required in existing building elements to accommodate equipment such as cables, raceways, bus ducts, cable trays, etc.
- .3 Arrange and pay for cutting and patching as required for the Work. Before cutting, drilling, or sleeving structural load bearing elements, obtain the Consultant's approval of location and methods in writing. Employ original installer or expert in the finishing of material required to perform cutting or patching for weather-exposed, moisture-resistant elements or sight-exposed surfaces.

12.2 Structure Scanning and Cutting

- .1 Layout cutting of structural elements, such as floor slabs, walls, columns or beams and obtain approval before starting work. Conduct an initial electromagnetic or ground-penetrating radar scan of reinforcing rods and electrical conduit, such as by use of Hilti PS200/250 Ferrosan, and review with Structural Engineer.
- .2 Layout cutting of structural elements, such as floors slabs, walls, columns or beams and obtain approval before starting work. Conduct an initial electromagnetic scan of reinforcing rods and electrical conduit, and review with structural engineering Consultant.

Standard of Acceptance

- Hilti - fig. PS 300 Ferrosan
- .3 Based on the preceding results, arrange and pay for supplemental radiographic examination where necessary to improve on locating concrete reinforcement, conduits and other embedment's.
 - .1 submit radiographic results to the structural engineer and obtain comments before starting work,
 - .2 the use of radiographic imaging methods is subject to approval by the Owner on a case by case
- .4 As an alternative to radiographic examination for areas where the Owner does not permit radiographic examination, based on the preceding results, provide two-dimensional ground penetrating radar scans to locate concrete reinforcement, conduits and other embedment's. Scanners to be operated by personnel trained by the measurement device manufacturer.

Standard of Acceptance

- Hilti PS1000 X-SCAN
- .5 Relocate core drilling location if steel, conduit or other embedment is found in the proposed location and repeat procedure. Repair and reroute any circuits damaged by core drilling.
- .6 Scan for all shots and anchors in floors, walls, and ceilings.

13 PROTECTION OF PERSONNEL, WORK, AND PROPERTY

13.1 Personnel Protection

- .1 Without limiting the Contractor's responsibilities regarding occupational health and safety requirements at the construction site, provide specific personnel protection as follows:
 - .1 protect exposed live equipment during construction for personnel safety,
 - .2 shield and mark live parts "LIVE 120 VOLTS", or with appropriate voltage,
 - .3 arrange for installation of temporary doors for rooms containing electrical distribution equipment. Keep these doors locked except when under direct supervision of electrician,
 - .4 do not leave conduit, wires, cables, tools, equipment or materials in such a way that they constitute a hazard,
 - .5 provide toe guards around openings in the roof or floor to prevent materials or debris from dropping down to a lower level,
 - .6 remove loose equipment and tools from overhead areas before leaving each day,
 - .7 cut off bolts at floor level to eliminate a possible tripping hazard.

13.2 Protection During Construction

- .1 Provide protection required to enable existing building and equipment to remain in continuous and normal operation.
- .2 Take the necessary precautions to protect equipment, existing building and service from damage during the Work. Accept responsibility for any damage and make good without cost to the Owner.
- .3 Protect existing surfaces and items so that they are not damaged in any way whatsoever by the work of all trades. Take precautions as necessary to prevent damage to walls, floors, ceilings, windows, doors, door frames, moldings, finishes, piping, ductwork, light fixtures, etc. Provide protection, hoarding, tarpaulins, dust sleeves etc., as required. Any damage caused because of lack of adequate protection to be made good at no cost to the Owner.
- .4 Take care when working above or around equipment that must remain in service.
- .5 Take care to eliminate dust in equipment areas.

- .6 Protect switchgear fronts from accidental breaker trips when working around or above them. Provide an extended shield constructed of 12 mm (½") fire retardant plywood a minimum of 450 mm (18") from board front to allow access to board.

13.3 Core Drilling

- .1 Wherever core drilling is required, provide temporary dust proof screens.
- .2 In areas where core drilling through a slab in an operating facility is necessary, clearly mark out the areas to be drilled on the underside of slab. Owner's representative to be notified at least 1 week prior to core drilling operation. Provide tarping of equipment supervised by the Owner.
- .3 During core drilling operations, station at least one person directly below the area of drilling with a large plastic container pressed to underside of slab to capture and hold core and water upon completion of operations.
- .4 Continuously use a wet/dry commercial quality vacuum at location of drilling operation to remove all excess water from the area.

13.4 Temporary Dust Proof Screens

- .1 Provide temporary dust proof screens in accordance with Specification section 01 56 00 *Temporary Barriers and Enclosures*.

13.5 Protection of Floors During Equipment Installation

- .1 Provide protection of floor finishes during installation or removal of equipment, and at any other time when moving or installing heavy equipment.
- .2 Install 19mm (¾") plywood over 6 mil plastic over finished floor areas when moving heavy equipment that could damage floor finish, or when installing equipment or line materials overhead.
- .3 Repaint or re-tile any floors or walls damaged or scratched during construction.

13.6 Housekeeping

- .1 Maintain a high level of cleanliness.
- .2 Remove scrap and refuse from the work area daily.
- .3 Whenever possible, clean up immediately following completion of work.
- .4 Deposit oily and waste solvent rags in approved containers to minimize the fire hazard.
- .5 Sweep and damp mop daily.

14 WORK IN EXISTING BUILDING

14.1 General

- .1 Comply with Specification section 01 35 13 for restrictions on working in existing occupied buildings and as follows.
- .2 During the tender period, perform a site inspection of the place of work and surroundings including the accessible ceiling spaces and other areas where access could be considered reasonable. Make a thorough investigation of the as built conditions to determine the scope of renovation and demolition work required prior to submitting a tender.
- .3 The Work includes changes to the existing building and changes at junction of old and new construction. Route cabling, ducts, conduits and other services to avoid interference with existing installation.
- .4 Perform core drilling at a time coordinated with Owner. Assume after-hours work for core drilling.

- .5 Relocate existing pipes, ducts, conduits, bus ducts and any other equipment or services as necessary to accommodate the Work.
- .6 Maintain or relocate existing services which pass through the area of renovation or demolition, but which feed items located outside of these areas. Rewire devices to the original circuits.
- .7 Remove existing lighting fixtures, wiring, devices and equipment to suit new construction. Cut back and cap conduits and electrical outlets not being used, so that finished work presents a neat and clean appearance. Disconnect at point of electrical supply, remove obsolete wiring and conduits, and make existing systems safe. Blank off openings in panels or boxes created by the removal of cables, conduits, wireways or ducts.
- .8 Where an existing ceiling is to be removed and reinstalled or replaced under another trades scope of work, and the existing electrical items such as luminaires, fire detectors, speakers, exit signs, emergency lighting heads etc., are to be reused, provide the following regarding the electrical items:
 - .1 remove,
 - .2 store in a secure, clean, dry location,
 - .3 install in the new ceiling, extend wiring and raceways as necessary,
 - .4 provide new items to match existing where existing items have been lost or damaged,
 - .5 make connections,
 - .6 clean,
 - .7 relamp luminaires,
 - .8 test,
 - .9 verify fire alarm devices,
 - .10 replace defective items with new, then retest/reverify,
 - .11 submit test and verification reports.
- .9 Unless noted otherwise removed materials and equipment become the property of the Contractor and are to be taken from the site and disposed of appropriately.
- .10 Review removed luminaires and equipment with the Owner's representative, and if the Owner instructs they wish to keep any items, move them to a designated location on the site. Luminaires and equipment that the Owner does not want become the property of the Contractor and are to be taken from the site and disposed of appropriately.
- .11 For devices, fixtures and equipment to be relocated, provide junctions boxes, outlet boxes, wiring, plates, supports, etc., as necessary.
- .12 Revise panelboard directories accordingly if affected by the Work.
- .13 Clean and relamp relocated luminaires and replace any faulty ballasts.
- .14 On completion of relocations, confirm that relocated devices and luminaires are in proper working order.
- .15 Co-ordinate work affecting fire alarm system, fire safety, or protection systems with the Owner, Consultant, fire alarm system manufacturer and authorities having jurisdiction prior to commencing work. Retain the original fire alarm system manufacturer to verify relocated fire alarm devices, modified equipment and revised wiring. Provide temporary fire protection and/or a fire watch in all areas affected by the demolition and as required by authorities having jurisdiction.
- .16 Where the Owner wishes to take over renovated areas ahead of the project completion date and these areas are intended to be fed from the distribution systems in the new building, make temporary connections to the existing services in these areas. Reconnect to permanent services at a later date, when the new distribution systems are available.

14.2 Continuity of Services

- .1 Keep existing buildings in operation with minimum length of shutdown periods.
- .2 Make connections to existing systems at approved times.
- .3 Obtain written approval, recording times when connections can be made.
- .4 Arrange the Work so that physical access to the existing buildings is not unduly interrupted.
- .5 Be responsible for and make good any damages caused to existing systems when making connections.
- .6 Provide premium time labour to tie-in feeders or wiring at night or on weekends.
- .7 Provide temporary feeders and connections as required to maintain systems in operation where shutdown periods will exceed 8 hours, or extend beyond the allowable time frame determined by the Owner.

15 MOVING AND SETTING IN PLACE OWNER'S EQUIPMENT

15.1 General

- .1 The requirements of this Part applies to;
 - .1 Division 26 equipment that has been pre-tendered or pre-purchased by the Owner, and
 - .2 other Owner-supplied products or equipment (i.e. process equipment) that has building services requirements.
- .2 Comply with the requirements of Specification section of 01 11 00 *Summary of Work* and as specified herein.

15.2 Supplied by Owner Equipment (SBO)

- .1 Items marked SBO on drawings are to be;
 - .1 purchased by the Owner,
 - .2 received, checked, stored, by the Contractor, and
 - .3 subsequently unpacked, uncrated, assembled and located in its final location by the Contractor, and installed in accordance with the manufacturer instructions,
 - .4 participate in the start-up and testing of the equipment and placing into service.
- .2 Provide electrical services to this equipment.

15.3 Existing Owners Equipment to be Relocated (E.R. or Ex. Rel.)

- .1 Applies to owners existing equipment which has mechanical and electrical services, and marked on the drawings as E.R. Ex.Rel. or otherwise so identified.
- .2 Except as indicated below, items so marked on drawings will be moved from their present location and reinstalled by the Contractor. Disconnect and reconnect electrical services to accommodate the relocation of this equipment.
- .3 Disconnect, remove, store as necessary, move into place, reinstall, clean and reconnect electrical items so marked, such as;
 - .1 luminaires,
 - .2 fire detectors,
 - .3 speakers,
 - .4 switches,

- .5 receptacles,
- .6 disconnects,
- .7 splitters,
- .8 panelboards,
- .9 switchgear,
- .10 transformers,
- .11 etc.

16 CONSTRUCTION POWER AND TEMPORARY ELECTRICAL SERVICES

16.1 Temporary Power Service

- .1 Temporary power services are provided under section 01 51 00 *Temporary Utilities*.

16.2 Temporary Construction Power and Lighting

- .1 Temporary electrical power distribution is provided under section 01 51 00.

17 FINAL CLEANING

17.1 Final Cleaning

- .1 Conduct final cleaning in accordance with Division 01 requirements and as specified herein.
- .2 Perform final cleaning after construction activities that create dust have been completed.
- .3 Clean electrical equipment and devices installed as part of this project.
- .4 Clean lighting reflectors, lenses, and other lighting surfaces that have been exposed to construction dust and dirt, including the top surface, whether exposed or in the ceiling space.
- .5 Clean switch, receptacle, and communications outlets, coverplates, and exposed surfaces.
- .6 Clean and vacuum any smoke detectors exposed to construction dust, do not use compressed air.
- .7 Electrical rooms, generator enclosure, and electrical or communication closets:
 - .1 Thoroughly vacuum and clean interiors and buswork of switchboards, panels, cabinets and other electrical equipment of construction debris and dust prior to energization using a HEPA vacuum cleaner. Final clean using clean lint free cloths with a cleaning liquid as recommended by the manufacturer for the purpose.
 - .2 HEPA vacuum the top of switchboards, panels, cabinets, bus ducts, cable trays and conduits, and mechanical duct work in the room, followed by a thorough HEPA vacuuming of the floors. Thoroughly wash floors with wet mop and clean water. Control access to the room after cleaning. Provide temporary filter media on air supply ducts to these rooms to prevent re-contamination from other areas of construction.
 - .3 Thoroughly re-clean as necessary prior to final turn over.
 - .4 Do not lay permanent switchboard matting in electrical rooms until rooms are thoroughly re-cleaned, and floors wet mopped and dried, immediately prior to final turn over.

18 RECORD DRAWINGS

18.1 General

- .1 Maintain record drawings in accordance with Section 01 78 00 *Closeout Submittals* during the course of the Work and as follows.
- .2 A set of design drawings in AutoCad, Revit, or PDF format (as determined by the Consultant) will be provided by the Consultant. Record changes in actual installation as the Work progresses by the following method:
 - .1 make sets of white prints for each phase of Work and mark-up the print drawings, or
 - .2 revise the AutoCad or Revit file directly, and identify all changes made.
- .3 Mark-up these record drawings to provide dimensioned locations of drains, pipes, ductwork, conduit, manholes, foundations and similar buried items within the building, with respect to building column centres. Mark level with respect to an elevation which will be provided.
- .4 Retain on-site the survey information from excavation and backfill of site services, and after approval, transfer this information to the record documents.
- .5 Retain these drawings and make available to Consultant for periodic review.
- .6 At 50%, 75% and 90% project completion, scan marked-up drawings to PDF format and submit copy to the Consultant, or to the project on-line document management service if one is used.

18.2 As-built Drawings

- .1 Prior to testing, balancing and adjusting, transfer site record drawing information to a copy of the computer aided drafting/design program ("CAD") files, in the same software format used for the Consultants design drawings, to record final as-built condition.
- .2 Obtain a current set of CAD files from the Consultant, The Consultant's CAD files may not reflect all or any construction changes.
- .3 Drawings are to remain set to and follow Consultants CAD Standards - do not alter drawing scales, reference files, colours, layers or text styles,
- .4 Where items have been deleted, moved, renumbered or otherwise changed from contract drawings, revise the CAD files to record these changes. "Bubble" these revisions, and place these annotations on a separate and easily identified drawing layer.
- .5 Show on electrical as-built drawings final locations of conduit, outlets, panels, branch wiring, system wiring, pull boxes, bus ducts, and equipment.
- .6 Show on site services as-built drawings survey information provided by an accredited land surveying service.
- .7 Identify each drawing in lower right hand corner in letters at least 12 mm (½") high with a note as follows:

<p style="text-align: center;">AS-BUILT DRAWINGS. This drawing has been revised to show systems as installed (Signature of Contractor) (Date).</p>
--

- .8 Submit one (1) set of white prints of the draft as-built CAD files for the Consultant's review.
- .9 Once "AS BUILT DRAWINGS" white prints are reviewed, transfer Consultant's comments to the CAD files. Return CAD files modified to "As Built" condition to Consultant in electronic format by removable mass storage device or by electronic file transfer as designed by the Consultant.

- .10 Submit three (3) sets of white prints and one (1) electronic copy of CAD files with Operating and Maintenance Manuals to the Owner.

19 OPERATING AND MAINTENANCE INSTRUCTIONS

19.1 Operating and Maintenance Data

- .1 Provide operating and maintenance manuals in accordance with Section 01 77 00 *Closeout Procedures* and as follows.
- .2 Provide operation and maintenance data bound in vinyl covered, hard back, three-ring covers, nominally 50 mm (2 in) thick, suitable for paper size of 210 mm x 300 mm (8½ in x 11 in)
 - .1 Organize material in volumes, generally grouped by Division Section;
 - (a) Table of Contents
 - (b) General Information
 - (c) Sub-contractors (list)
 - (d) Site services,
 - (e) Power,
 - (f) Lighting,
 - (g) Low Voltage Systems,
 - (h) Fire Alarm,
 - (i) Security,
 - (j) Testing Reports,
 - (k) As-Built Drawings,
 - (l) Warranties.
 - .2 Title sheet in each volume to be labeled "Operating and Maintenance Manual" and to bear;
 - (a) Project Name,
 - (b) Project Number,
 - (c) Date,
 - (d) Trade Section, and
 - (e) List of Contents.
 - .3 Provide three hard-copies to Owner.
- .3 In addition, provide PDF files for each document, produced from original direct-to-digital file creations.
 - .1 Organize documents into separate PDF files for each Division Section identified above, and apply PDF Bookmarks to create a Table of Contents.
- .4 Operating and maintenance data to include;
 - .1 details of design elements, construction features, component function and maintenance requirements, to permit effective start-up, operation, maintenance, repair, modification, extension and expansion of any portion or feature of installation,
 - .2 technical data, product data, supplemented by bulletins, component illustrations, exploded views, technical descriptions of items, and parts lists; advertising or sales literature not acceptable,
 - .3 wiring and schematic diagrams and performance curves,
 - .4 names and addresses of local suppliers for items included in maintenance manuals,
 - .5 reviewed shop drawings,

- .6 operating characteristics of the equipment supplied such as calibration curves and coordination data to allow proper co-ordination with Owner's equipment,
 - .7 description of operation of the controls and protective devices used,
 - .8 maintenance and adjustment procedures,
 - .9 lifting and jacking instructions,
 - .10 fault locating guide,
 - .11 spare parts list and an itemized price list,
 - .12 name and telephone numbers of service organization and technical staff that will provide warranty service on the various items of equipment.
- .5 Approval procedure;
- .1 submit one set of first draft of Operating and Maintenance Manuals for approval at least one month prior to planned substantial performance date,
 - .2 make corrections and resubmit for a final review,
 - .3 review contents of Operating and Maintenance Manuals with Owner's operating staff or representative to ensure thorough understanding of each item of equipment and its operation,
 - .4 hand-over two (2) copies and one (1) PDF copy on removable storage device of the Operating and Maintenance Manuals to the Owner's operating staff and obtain written confirmation of delivery. Provide a copy of the delivery record to the Consultant.

19.2 Operating and Maintenance Training

- .1 Provide operating and maintenance training in accordance with Section 01 79 00 *Demonstration and Training* and as follows.
- .2 Provide training to Owner's operations staff to thoroughly explain operation and maintenance of each system, incorporating specialized instruction by manufacturers as described under other Sections. Include classroom instruction and hands-on instruction, delivered by competent instructors.
- .3 Develop the proposed training plan, and submit an outline of the training program for review and adjustment by the Owner. Obtain approval from the Owner before commencing training.
- .4 Structure each session to start with the classroom instruction for the overall system, followed by hands-on instruction for each item of equipment, utilizing the services of the manufacturers' representative as required.
- .5 Organize and schedule each training session to deliver the required instruction in an efficient and effective manner on a schedule agreed upon with the Owner. Allow for two (2) training sessions for each training topic, separated by approximately one week each. Develop the proposed training plan and obtain approval from the Owner before commencing training.
- .6 All training to be scheduled and provided between the hours of 7 am to 5 pm, Monday to Friday. Where training is required to be performed outside of these hours due to availability of Owners operations personnel, if the trainers are paid for overtime outside of these hours, the overtime portion only is eligible to be paid by the Owner as an extra cost.
- .7 Complete the training as close to Substantial Performance as possible, so that the operations staff are prepared to operate the systems after Substantial Performance is certified.
- .8 Organize each pair of training sessions as follows:
 - .1 Power Distribution - Division 26
 - .2 Communications – Division 27
 - .3 Electronic Safety and Security – Fire Alarm – Division 28
 - .4 Electronic Safety and Security – Security – Division 28

- .9 Keep a record of date and duration of each instruction period together with names of persons attending. Submit signed records at completion of instruction.
- .10 For each training session, include the following topics;
 - .1 general purpose of the system (design intent),
 - .2 use of O & M manuals,
 - .3 review of single line drawings and control schematics,
 - .4 start-up, normal operation, shutdown, unoccupied operation, seasonal changeover, manual operation, control set-up and programming, troubleshooting and alarms,
 - .5 interaction with other systems,
 - .6 adjustments and optimizing methods for energy conservation,
 - .7 maintenance requirements,
 - .8 special maintenance and replacement sources,
 - .9 health and safety issues,
 - .10 occupancy interaction issues, and
 - .11 system response to different operating conditions.
- .11 Develop and provide training material, including printed documents and electronic presentation aids (e.g. MS PowerPoint) for each session. Submit three (3) copies of materials in both hardcopy and PDF format, in accordance with article on Operating and Maintenance Manuals.
- .12 Sessions may be videotaped by the Owner as an aid to ongoing training of Owner's staff.

20 CARE, OPERATION AND START-UP

- .1 Provide all labour and materials as necessary to perform start-up and testing of equipment and systems.
- .2 Arrange and pay for services of manufacturer's factory service technicians to supervise start-up of installation, check, adjust, balance and calibrate components and equipment as specified in the specification sections of Division 26.
- .3 Provide these services for such periods, and for as many visits as necessary to put equipment in operation, and ensure that operating personnel are conversant with every aspect of the operation, care and maintenance thereof.
- .4 Arrange and pay for services of applicable manufacturer's factory service engineer or certified independent testing organization to supervise initial start-up of specialized portions of installation and to check, adjust, balance and calibrate components including related wiring and controls. Provide these services for such periods, and for as many visits as may be necessary to put applicable portion of the installation in complete working order. Provide a certificate indicating that the equipment is free and clear of deficiencies.

21 TESTING

21.1 General

- .1 The following describes the general requirements for testing of electrical systems; refer to additional testing requirements in applicable sections of Division 26 of the Work.
- .2 Conduct and pay for the following tests;
 - .1 power distribution system including phasing, voltage, grounding and load balancing,
 - .2 circuits originating from branch distribution panels,

- .3 lighting and its control,
- .4 motors, heaters and associated control equipment including sequenced operation of systems where applicable,
- .5 systems: fire alarm system, communications,
- .6 additional testing as specified in other Sections.
- .3 Furnish manufacturer's certificate or letter confirming that entire installation as it pertains to each system has been installed to manufacturer's instructions.
- .4 Insulation resistance testing;
 - .1 megger circuits, feeders and equipment up to 350 V with a 500 V instrument,
 - .2 megger 350-600 V circuits, feeders and equipment with a 1000 V instrument,
 - .3 check resistance to ground before energizing.
- .5 Carry out tests in presence of Consultant.
- .6 Provide instruments, meters, equipment and personnel required to conduct tests during and at conclusion of project.
- .7 Submit test results for Consultant's review. Test electrical equipment to standards and function of specifications, applicable codes and standards in an approved manner. Replace defective equipment and wiring with new material and leave entire system in complete first class operating condition.

21.2 Testing of Integrated Life Safety and Fire Protections Systems

- .1 Conduct testing of integrated life safety and fire protection systems in accordance with specification Section 26 08 11 *Testing of Integrated Electrical Life Safety and Fire Protection Systems* .

22 LOAD BALANCE

- .1 Measure phase current to panelboards with normal loads (lighting) operating at time of acceptance. Adjust branch circuit connections as required to obtain best balance of current between phases and record changes. Revise circuit labelling as appropriate.
- .2 Measure phase voltages at loads and adjust transformer taps to within 2% of rated voltage of equipment.
- .3 Submit, at completion of work, report listing phase and neutral current on panelboards, dry-core transformers and motor control centres, operating under normal load. State hour and date on which each load was measured, and voltage at time of test.

23 CO-ORDINATION OF PROTECTIVE DEVICES

- .1 Ensure circuit protective devices such as overcurrent trips, relays and fuses are installed to required values and settings as per equipment manufacturers' recommendations for each piece of equipment.

24 COMMISSIONING

- .1 Participate in commissioning of equipment and systems in accordance with Section 26 08 15 *Electrical Commissioning*.
- .2 Equipment supplied on this project will be subject to detailed factory inspection and/or on-site testing and commissioning prior to being placed in service. The electrical contractor, their major system and equipment suppliers, and the Independent Testing Agent (ITA) will be required to participate in special commissioning meetings to review progress and status of the commissioning program.
- .3 Include in Bid amount for licensed electricians to participate in the commissioning program, to undertake temporary power connections, operation of equipment, opening and closing of panel boards

and switchboards, testing of power and control wiring, and assisting the ITA and the equipment suppliers' field personnel in the startup and testing of the equipment.

- .4 The contractor and equipment suppliers to include in the Bid amount the costs to accommodate and undertake factory and site testing.

25 TEMPORARY AND TRIAL USAGE

- .1 Temporary and trial usage by Owner of any electrical device, machinery, apparatus, equipment or any other work or materials before final completion and written acceptance, is not to be construed as evidence of acceptance by the Owner.
- .2 Owner to have the privilege of such temporary and trial usage, as soon as the Contractor claims that said work is completed and in accordance with specifications, for such reasonable length of time as is deemed to be sufficient for making a complete and thorough test of same.
- .3 No claims will be considered for damage to or failure of any parts of such work so used which may be discovered during temporary and trial usage, whether caused by weakness or inaccuracy of structural parts or by defective materials or workmanship of any kind whatsoever.
- .4 Defects in workmanship and materials identified during temporary and trial usage are to be rectified under warranty.

26 CONSULTANT REVIEWS

26.1 General

- .1 Consultant's attendance at site including but not limited to site meetings, demonstrations, site reviews and any resulting reports are for the sole benefit of the Owner and as required by the local authority have jurisdiction. It is the Contractor's responsibility to ensure that the Work is complete and constructed in accordance with the design documents.

26.2 Site Reviews

- .1 General reviews and progress reviews do not record deficiencies during the course of the Work until such time as a portion or all of the work is declared complete. In some instances, before the work is completed, readily noticeable deficiencies may be recorded by the Consultant where the deficient item is indicative of issues such as poor workmanship, incorrect materials or installation methods, or may be difficult to correct at a later date. Any such reported items, or lack thereof, shall not be relied on in any way as part of the Contractors quality assurance program nor relieve the Contractor in the performance of the Work, specifically in identification and rectification of deficiencies or incomplete Work.
- .2 Deficiency reviews conducted by the Consultant are performed on a sampling basis, and any deficiency item is to be interpreted as being indicative of similar locations elsewhere in the Work, unless indicated otherwise.

26.3 Milestone Reviews

- .1 Specific milestone reviews may be conducted at key stages by the Consultant, including;
 - .1 before backfilling of buried services,
 - .2 before closing of shafts,
 - .3 before closing of walls,
 - .4 before closing of ceilings,
 - .5 equipment demonstration,
 - .6 Substantial Performance deficiency review,

- .7 Total Performance deficiency review.
- .2 Coordinate with the Consultant the type and quantity of milestone reviews required and incorporate these requirements into the construction schedule.
- .3 Prior to Work being concealed, notify the Consultant in writing seven (7) calendar days in advance of the planned concealment to arrange a site review, where required by the Consultant. Correct noted deficiencies before concealing the Work. Failure to provide notification can result in the Work being exposed for review at the Contractor's cost.

26.4 Partial Occupancy Reviews

- .1 Where the Work is planned to include occupancy by the Owner of a part of the Work but not the entire Work ("partial occupancy"), the procedures specified for Substantial Performance Review will apply to the portion of the Work being considered for partial occupancy.

26.5 Substantial Performance Review

- .1 At the time of applying for project Substantial Performance, submit to Consultant a comprehensive list of items to be completed or corrected.

26.6 Final Review

- .1 At project completion submit written request for final review of electrical systems. Refer to section 26 08 19 Project Close-Out.
- .2 Include with the request a written certification that;
 - .1 deficiencies noted during job inspections have been completed,
 - .2 systems have been balanced and tested and are ready for operation,
 - .3 completed maintenance and operating data have been submitted and approved,
 - .4 equipment/line material tags are in place and equipment identification is completed,
 - .5 cleaning is finished in every respect,
 - .6 electrical panels, switchboards, cabinets, and equipment surfaces have been touched up with matching paint, or re-finished as required,
 - .7 spare parts and replacement parts specified have been provided and receipt acknowledged,
 - .8 As-built and Record drawings are completed and approved,
 - .9 Owner's operating personnel have been instructed in the operation and maintenance of systems,
 - .10 fire alarm verification is 100% completed and Verification Certificate has been submitted and accepted.

27 CONTRACTOR INSPECTIONS

27.1 General

- .1 The Division 26 contractor shall assign one person responsible for ensuring that Work from all electrical trades is complete prior to;
 - .1 closing in wall, ceilings or burying of services,
 - .2 partial-occupancy reviews, and
 - .3 substantial performance reviews.
- .2 In conjunction with the Contractor's Mechanical and Electrical sub-contractors, the Contractor shall walk the site and thoroughly inspect that the work is complete, in good workmanship and installed according to the contract documents and derived documents therefrom. The Contractor shall then

submit a report attesting to the completed state of the Work (the "Statement of Completion" report, as detailed later in this part).

- .3 In the case of Contractor inspections for partial-occupancy or substantial performance, submit the Statement of Completion report at least 24 hours prior to the scheduled review by the Consultant.

27.2 Concealed Space Digital Image Records

- .1 Where services are to be concealed behind walls, ceilings, or buried, the Contractor shall make a digital photo or digitally scanned record of the Work, and assemble these digital records in a logical file structure, organized by floor or department, with each record filename including the room number, so as to form a comprehensive documentation of the completed services.
- .2 The digital files and folders are to be turned over to the Consultant for review prior to the Consultant's reviews for partial- occupancy or substantial performance.
- .3 As part of the request for substantial performance of the Work, submit two (2) copies of the digital record on separate removable storage devices to the Owner for their use. These records are in addition to other construction records including as-built documentation.

27.3 Contractor Inspections for Partial Occupancy and Substantial Performance

- .1 In preparation for the Consultants general review for partial-occupancy and/or substantial performance of the Work, the Contractor shall perform a comprehensive inspection of the Work to ensure that their contractual obligations are met before requesting a Consultant's review of the Work. In performing this inspection, the Contractor shall create a Statement of Completion report which is to include;
 - .1 date and time of the Contractor's inspection, signed by the person who conducted the inspection,
 - .2 names of the electrical contractor's personnel who participated in the inspection,
 - .3 confirmation that previously noted deficiencies have been completed,
 - .4 confirmation that the work is 100% complete, tested, balanced and free of deficiencies, or include a list of outstanding deficiencies and incomplete Work with;
 - (a) a reason why the Work has not been completed (i.e. another trade has to complete their work)
 - (b) a plan of action to complete the Work, and
 - (c) a commitment date for completion of the Work including rectification of all deficiencies.
- .2 The format of the Statement of Completion shall be approved by the Consultant.
- .3 The Consultant shall review and sign-off the Statement of Completion Report and return a copy to the Contractor. The Contractor shall retain on-site a log of all signed off Statement of Completion reports.
- .4 If a required Statement of Completion report is not received, the Consultant reserves the right to withhold conducting a review for partial-occupancy or substantial performance.
- .5 After receipt of the Contractor's Statement of Completion report, if upon entering an area of the work covered by the Statement of Completion report the Consultant determines, in its sole opinion, that the applicable Work is not ready for review, the Consultant may elect to cancel the review of the Work or the affected portion of the Work, and shall assume no responsibility for any damages or losses as a result of cancellation of the review. The Contractor shall remedy the incomplete work and request another review with 72 hours prior written notice, and shall resubmit the revised Statement of Completion at least 24 hours prior to the new review.

28 CORRECTION AFTER COMPLETION

28.1 General

- .1 At completion, submit a written warranty, undertaking to remedy defects in work for a period of one year from date of substantial performance of the Work. This warranty is not to supplant other warranties of longer period called for on certain equipment or materials.
- .2 Warranties are to encompass replacement of defective workmanship, parts, materials or equipment, and to include incidental fluids, gaskets, lubricants, supplies, and labour for removal and reinstallation of the corrected Work.
- .3 Submit similar warranties for one year from date of acceptance for any part of work accepted by Owner, before completion of the whole Work.

29 ATTACHEMENTS

29.1 Schedule of Values Form

- .1 Attached sample of the Schedule of Values form layout.

29.2 Shop Drawing Submittal Form

- .1 Attached sample of shop drawings submittal form.

SCHEDULE OF VALUES

Project Name: <<name of project>>
Owner Name: <<owner name>>
Contractor Name: <<name of trade contractor: mechanical, electrical, etc>>
Division(s) of the Work: <<i.e. 20, 21, 22...>>
For the billing period ending: dd-mmm-YYYY

This sheet is an example of a required schedule of values to be developed by the Contractor, to be submitted with each progress payment request.
Specific level of detail for each work element to be approved by the Consultant.

Item	Base Contract Element	Contract Value		Complete to Date		Previously Billed		This Billing		Balance to Complete	
		\$	%	\$	%	\$	%	\$	%	\$	%
1.1	<<work element>>	1,000,000.00	65.9%	400,000.00	40.0%	225,000.00	22.5%	175,000.00	17.5%	600,000.00	60.0%
1.2	<<work element>>	250,000.00	16.5%	30,000.00	12.0%	5,000.00	2.0%	25,000.00	10.0%	220,000.00	88.0%
1.3	<<work element>>	125,000.00	8.2%	50,000.00	40.0%	22,000.00	17.6%	28,000.00	22.4%	75,000.00	60.0%
X.X	Itemized Price No. 1	25,000.00	1.6%	0.00	0.0%	0.00	0.0%	0.00	0.0%	25,000.00	100.0%
X.X	Separate Price No. 1	12,500.00	0.8%	5,000.00	40.0%	0.00	0.0%	5,000.00	40.0%	7,500.00	60.0%
CCA.1	Cash Allowance Disbursements Summary	75,000.00	4.9%	34,000.00	0.0%	8,000.00	0.0%	26,000.00	0.0%	41,000.00	0.0%
X.X	Coordination drawings	15,000.00	1.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	15,000.00	100.0%
X.X	As-built documents and operating manuals	15,000.00	1.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	15,000.00	100.0%
Original Contract Values		1,517,500.00	100.0%	519,000.00	34.2%	260,000.00	17.1%	259,000.00	17.1%	968,500.00	63.8%
CO.1	Approved Changes Summary	13,400.00		5,200.00	38.8%	2,000.00	14.9%	3,200.00	23.9%	8,200.00	61.2%
Total Current Contract Values		1,530,900.00		524,200.00	34.2%	262,000.00	17.1%	262,200.00	17.1%	976,700.00	63.8%

Reference	Cash Allowance Disbursement	CA Value		Complete to Date		Previously Billed		This Billing		Balance to Complete	
		\$	%	\$	%	\$	%	\$	%	\$	%
CAA_1	<<description of cash allowance>>	20,000.00	100.0%	20,000.00	100.0%	8,000.00	40.0%	12,000.00	60.0%	0.00	0.0%
CAA_2	<<description of cash allowance>>	55,000.00	25.5%	14,000.00	25.5%	-	0.0%	14,000.00	25.5%	41,000.00	74.5%
Total		75,000.00		34,000.00	45.3%	8,000.00	10.7%	26,000.00	34.7%	41,000.00	54.7%

Reference	Approved Changes	Change Value		Complete to Date		Previously Billed		This Billing		Balance to Complete	
		\$	%	\$	%	\$	%	\$	%	\$	%
CO_01	<<description of change of work>>	5,800.00	0.0%	-	0.0%	-	0.0%	0.00	0.0%	5,800.00	100.0%
CD-01	<<description of change of work>>	7,600.00	68.4%	5,200.00	68.4%	2,000.00	26.3%	3,200.00	42.1%	2,400.00	31.6%
Total		13,400.00		5,200.00	38.8%	2,000.00	14.9%	3,200.00	23.9%	8,200.00	61.2%

Reference	Unquoted/Unapproved Changes	Status	Quotation	
			\$	
CCN=01	<<description of change of work>>	Waiting for approval	12,000.00	
CCN=02	<<description of change of work>>	Unquoted		
Total			12,000.00	



Toronto Montreal Vancouver Dallas Chicago

SHOP DRAWING SUBMITTAL

***Include this cover page with each shop drawing submission.
Submissions without this form will be returned without review.
Submit one submittal form per shop drawing; do not group under one submittal sheet***

Client/Architect: Click or tap here to enter text.

Project Name: Click or tap here to enter text.

HHA Project No: Click or tap here to enter text.

Contractor to complete the following for each submission.

Date: _____

Contractor Name: _____ Ref. No: _____

Manufacturer Name: _____

Product Type/Description: _____

Specification section number: _____

Contractor Trade Category:

- | | | | |
|--|-------------------------------------|--|---|
| <input type="checkbox"/> Architectural | <input type="checkbox"/> Structural | <input type="checkbox"/> Conveying Equipment | <input type="checkbox"/> User Equipment |
| <input type="checkbox"/> Mechanical | <input type="checkbox"/> Electrical | <input type="checkbox"/> Telecommunications | <input type="checkbox"/> Civil |
| <input type="checkbox"/> Other | | | |

If this is a resubmission, check here: ☐

Previous submission HHA reference no.: _____

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END OF SECTION

Issued For Bid and Permit

ELECTRICAL BASIC MATERIALS AND METHODS

26 05 01

1 GENERAL

1.1 Scope

- .1 Articles that are of a general nature, apply to each Section of Divisions 26, 27 and 28.

2 ACCESS DOORS

2.1 Construction

- .1 Access doors, unless shown or specified otherwise:
 - .1 constructed from galvanized steel sheet,
 - .2 flush mounted,
 - .3 concealed hinges,
 - .4 180° opening door,
 - .5 round safety corners,
 - .6 anchor straps,
 - .7 plaster lock,
 - .8 screwdriver operated latches,
 - .9 without visible screws,
 - .10 finished prime coat only.
- .2 Door metal thickness as follows:
 - .1 up to and including 400 x400 (16" x 16"): 1.6 mm (16 gauge)
 - .2 height or width larger than 400 (16"): 2 mm (14 gauge)
- .3 Constructed of stainless steel for areas finished with tile or marble surfaces.
- .4 Constructed of stainless steel with neoprene gasketed door where used in damp and high humidity areas.
- .5 Dish type door design to receive a tile insert where acoustic tile is applied to plaster or gypsum board ceilings.
- .6 Fire rated where installed in fire rated walls or ceilings. Fire rating to match the rating of the wall or ceiling.
- .7 With keyed cylinder locks, keyed alike, for areas subject to security risks, EG;
 - .1 public corridors,
 - .2 psychiatric patient areas,
 - .3 public washrooms,
 - .4 etc.
- .8 Inside clear dimensions:
 - .1 approximately 400 mm x 400 mm (16" x 16") for hand access,
 - .2 at least 600 mm x 600 mm (24" x 24") where personnel are to enter through doors,
 - .3 larger where indicated or required.

- .9 Submit access door shop drawings for approval as soon as possible after award of contract, showing size, type and exact location of access doors.

Standard of Acceptance

- Acudor
- Cendrex (up to 400 x 400 only)
- Elmdor (up to 400 x 400 only)
- Mifab (up to 400 x 400 only)
- Nystrom
- Williams Brothers – GP

2.2 Installation

- .1 Provide access doors for locations where equipment requiring access, maintenance or adjustment is "built-in".
- .2 Submit a list of proposed access door locations and obtain approval before commencing installation.
- .3 Access doors to be installed under the Division in whose work they occur. Arrange for and pay cost of access doors and their installation.
- .4 Access doors are not required in removable acoustic panel type ceilings.
- .5 Size and locate access doors in applied tile, or in glazed or unglazed structural tile to suit tile patterns. Refer to Architectural Room Finish Schedule and details on Architectural drawings in this regard.

3 SLEEVES AND CURBS

3.1 Materials

- .1 Sleeves for bus ducts, wireways and cable trays: minimum 3 mm (1/8") galvanized steel.
- .2 Integral flashing clamp on sleeves that pass through floors with a waterproof membrane.
- .3 Removable (non fire rated) sealing material: Duxseal or acceptable alternative.
- .4 Fire rated sealing material: per Article "Fire Stopping and Smoke Seals".

3.2 Installation

- .1 Provide sleeves for bus ducts, wireways, conduits and cable runs passing through;
 - .1 concrete walls, beams, slabs and floors,
 - .2 fire rated walls, partitions and ceilings.
- .2 Place and secure sleeves in concrete form work.
- .3 Supply sleeves to be set in concrete and masonry walls with installation detail drawings.
- .4 Terminate sleeves flush with surfaces of concrete and masonry walls.
- .5 Extend sleeves 100 mm (4") above finished floor.
- .6 Size sleeves to accommodate fire stopping materials where required.
- .7 Make watertight connections between sleeves and waterproof membranes.
- .8 Fill any spaces between sleeves and masonry walls;
 - .1 with non-shrink grout,
 - .2 with a rated fire stopping material for rated walls.

- .9 Seal spare sleeves and the space between sleeves and the through conduits, cables, wireways, bus ducts etc;
 - .1 using removable sealing material,
 - .2 using a rated fire stopping material for floors and rated walls,
 - .3 seal watertight where sleeves penetrate a floor slab.
- .10 Sleeves in existing concrete and masonry walls and floors;
 - .1 cutting and drilling of structural elements, such as floors, slabs, walls, columns, or beams to be carried out in accordance with procedure set out in Article "Cutting and Remedial Work" in Section "Electrical General Requirements",
 - .2 neatly cut or drill holes in existing construction,
 - .3 terminate sleeves flush with surfaces of concrete and masonry walls,
 - .4 extend sleeves 100 mm (4") above finished floor with flange, countersunk, and bolted down flush into floor surface,
 - .5 fill opening between sleeve and wall;
 - (a) with non-shrink grout,
 - (b) with a rated fire stopping material for rated walls.
 - .6 fill opening between sleeve and floor with rated fire stopping material with water barrier,
 - .7 seal as indicated above.
- .11 Provide concrete curbs, minimum 100 mm (4") high above finished floor surrounding sleeves and openings for;
 - .1 conduits,
 - .2 cables,
 - .3 telephone cable risers,
 - .4 bus ducts,
 - .5 wireways,
 - .6 cable trays, and
 - .7 other openings for electrical services through slabs above grade.
- .12 Size concrete curbs for bus ducts to provide sufficient area to adequately carry bus duct support brackets.
- .13 Size openings to accommodate fire stopping materials as required.

4 WALL AND FLOOR PLATES

4.1 General

- .1 Provide finishing plates fitted to electrical conduits and cables which pass through walls, floors and ceilings in finished areas.

4.2 Products

- .1 Escutcheons for small diameter electrical conduit:
 - .1 manufactured chrome plated two-piece split type with hinge and set-screw.
- .2 Finishing plates for electrical cables and large diameter electrical conduits:
 - .1 finishing plate (ring) fabricated from minimum 0.9 mm (20 ga) thick T304 stainless steel with No. 4 brushed finish, with minimum 25 mm (1 in) high collar ring,

- .2 mounting holes drilled at not less than three (3) symmetrically location positions around the ring to allow mechanical fastening,
- .3 plate diameter to be sufficiently sized to overlap the wall, floor or ceiling opening by not less than 25 mm (1 in) all around the opening.

4.3 Installation

- .1 Escutcheons:
 - .1 secure escutcheons to electrical conduit with mechanical fastener.
- .2 Finishing plates:
 - .1 set finishing plates flat against the finished surfaces, and secure to the surface with stainless steel pan-head mechanical fasteners. Provide insert anchor plugs in the finished surface as necessary to secure the fasteners.

5 FIRE STOPPING AND SMOKE SEALS

5.1 General

- .1 Maintain the integrity of floor and wall, fire separations and smoke seals, around EMT, conduits, electrical raceways, cables, bus ducts, boxes and any other electrical equipment passing through rated floors or walls.

5.2 Materials

- .1 Materials to form ULC or cUL listed/classified assemblies.
- .2 Materials to meet requirements of CAN/ULC-S115 "Standard Method of Fire Tests of Firestop Systems".
- .3 Firestop system rating: minimum 2 hrs., higher where indicated.
- .4 Materials installed in horizontal separations to be impervious to water.
- .5 Submit shop drawings consisting of product technical data and ULC or cUL listing.

Standard of Acceptance

- Hilti Firestop Systems
 - 3M
 - A/D Fire Protection System Inc.
 - Eastern Wire + Conduit
- .6 Other manufacturers having products with explicitly similar characteristics, listings or classifications and approvals are acceptable.

5.3 Installation

- .1 Submit a complete fire stopping and smoke seal schedule to the Consultant for review. Include details, cut sheets, system description and location for each proposed fire stopping and smoke sealing application.
- .2 Install firestopping and smoke seals in accordance with the manufacturer's recommendations and in accordance with the ULC or cUL listing.
- .3 Firestopping and smoke seals to be installed only by personnel trained by the manufacturer on the installation of such systems.
- .4 Firestop and smoke seal system manufacturer's training and inspection services:

- .1 Provide the services of the manufacturer to provide training to trades performing the fire stopping. Create and maintain a log of those personnel who obtain training.
- .2 Provide the services of the manufacturer to inspect the installation while in progress and a final inspection at completion of work. Provide a manufacturer's inspection report to the Owner and Engineer declaring that the installed firestop systems are in conformance to the manufacturer's system listing requirements.
- .5 Seal space between penetrating service and sleeve or opening in fire rated floors and walls with a fire stopping and smoke sealing system.
- .6 Select thickness and arrangement of back-up materials to suit size of service, length of sleeve and anticipated movement.
- .7 At time of application of materials, surfaces to be clean, dry and free from dust, oil, grease, loose or flaking paint, loose concrete or masonry and foreign materials.
- .8 Wiring may penetrate a fire rated assembly provided it is enclosed in non-combustible conduit, and the passage of the conduit in turn is suitably sealed to the assembly with fire stop and smoke sealing materials.
- .9 Where wiring with a combustible covering and not enclosed in non-combustible conduit penetrates a fire resistance rated assembly, group the wiring into separate fire and smoke sealed penetrations to ensure the overall diameter of the combined wire(s) in each penetration does not exceed 25 mm.
- .10 Arrange single conductor metal sheathed cables to individually penetrate the fire rated assembly and be individually fire stopped and smoke sealed. Where these cables have combustible jackets, space cables at least 300mm apart throughout the penetration.
- .11 Where wiring is installed in cable trays and penetrates a fire rated assembly;
 - .1 terminate and independently support the cable tray on each side of the fire rated assembly, and
 - .2 provide sufficient working room to properly install and inspect the fire stopping and smoke sealing materials.
- .12 Smoke seal and fire stop electrical boxes that penetrate a fire rated wall using fire rated putty pads, install putty pads on the outside of boxes.
- .13 Smoke seals and fire stopping in horizontal separations to be watertight with sleeves terminating not less than 100mm (4") above the finished floor.
- .14 Co-ordinate installation of cast-in-place fire stopping devices with the Division responsible for the placement of concrete.

6 SPRINKLER PROTECTION

6.1 Materials

- .1 Surface panelboards, switchboards and other electrical equipment in sprinklered areas to be fitted with watertight hubs with insulated throat, for each conduit entrance.

Standard of Acceptance

- ABB Installation Products Ltd. (T & B) - Series 401
 - Efcor of Canada Ltd. - Series 40-50B
- .2 Provide equipment in sprinklered areas, with hoods or shields and gasketed doors for protection against entry of sprinkler discharge, and to comply with the requirements of the electrical code, alternatively, and where indicated, provide indoor weatherproof equipment.
 - .3 Ventilation openings to be overhanging drip proof type.

- .4 Indoor weatherproof equipment, where noted in the specifications and/or drawings to have CSA type 3R enclosures in accordance with the requirements of CSA Standard C22.2 No. 94.

7 PENETRATIONS OF BELOW GRADE WALLS AND SLABS ON GRADE

7.1 Materials

- .1 Expanding cement water stop material.
- .2 Submit manufacturer's literature.

Standard of Acceptance

- Cetco WATERSTOP-RX
- W.R. Meadows WATERSTOP EC PLUS
- or acceptable equivalent

7.2 Installation

- .1 Fit each cable, conduit and duct passing through floor slab in contact with ground or walls below grade, with a water stop.
- .2 Submit schedule showing location, service.
- .3 Install water stop in accordance with the manufacturer's instructions.
- .4 Encircle each cable, conduit and duct and the perimeter of the wall opening with the water stop material.
- .5 Fill the wall openings around the cables, conduits or ducts with hydraulic cement injected for the full width of the wall.
- .6 Seal the exterior of the wall around the cables, conduits or ducts with a waterproof coating. Waterproof coating to be compatible with any existing waterproofing.

8 EQUIPMENT SUPPORTS, AND BASES

8.1 Supports for Electrical Work

- .1 Equipment supplementary supports to be provided by this Division.
- .2 Concrete housekeeping bases for electrical equipment to be provided by this Division.
- .3 Work to be done by firms specializing in these fields.
- .4 Submit shop drawings for steel and concrete work, prepared by licensed Professional Engineers.

8.2 Supplementary Supports and Support Brackets:

- .1 Fabricated from structural grade steel with anchor bolts and fastenings.
- .2 Designed in consultation with building structural consultant to transfer live loads and dead loads to building structural elements.
- .3 Constructed as frames bracketed from walls, and/or supported from building structure above, and/or floor below.

8.3 Concrete Bases for Housekeeping Pads

- .1 Constructed using plywood form work and 20 Mpa (3000 lb) concrete.
- .2 Dowelled to concrete floor slab with steel rods not less than 13 mm (1/2 in) in diameter. For existing concrete floors, floors are to be drilled and dowels secured in the holes with chemically-hardening adhesive.

- .3 Refer to Specification section 26 05 49 *Seismic Restraint for Electrical Systems* for additional requirements for housekeeping pads where equipment is to be seismically restrained.
- .4 Finish to make flat, level, smooth, neat surfaces.
- .5 Chamfer corners 25 mm (1 in).
- .6 Dimensions:
 - .1 75 mm (3 in) larger all around than base of apparatus for non-seismic applications,
 - .2 minimum 200 mm (8 in) larger all around than equipment-base anchor attachment points for seismically restrained equipment.
 - .3 height: 100 mm (4 in)

8.4 Installation

- .1 Locate supporting steel to permit service or repair, and to allow clear access to junction boxes and equipment.
- .2 Set equipment on supporting frames and brackets and install hangers, anchor bolts, and vibration mountings.
- .3 Install anchor bolts, and vibration mountings between equipment and housekeeping pad.
- .4 Erect metalwork square, plumb, straight, and true, accurately fitted, with tight joints and intersections.
- .5 Provide anchorage, dowels, anchor clips, bar anchors, expansion bolts and shields, and toggles.
- .6 Make field connections with bolts to CAN/CSA-S16.1, or weld.
- .7 Supply items for casting into concrete or building into masonry to appropriate trades together with setting templates.
- .8 After completion of erection, touch-up field welds, bolts and burnt or scratched surfaces with primer.
- .9 Where gratings or trench covers are cut in field or damaged, touch up with zinc rich paint.

9 GENERAL WIRING REQUIREMENTS

9.1 Wiring Terminations

- .1 Lugs, terminals, screws used for termination of wiring to be suitable for either copper or aluminum conductors.
- .2 Manufacturers' and CSA labels to be visible and legible after equipment is installed.

9.2 Location of Outlets

- .1 Locate outlets in accordance with Division 01 - General Requirements.
- .2 Do not install outlets back-to-back in wall.
- .3 Where back boxes on opposite sides of a wall occupy the same stud bay, apply acoustical putty pads to the outside of the boxes.
- .4 Change location of outlets at no extra cost or credit, providing distance does not exceed 3000 mm (10'), and information is given before installation.
- .5 Locate light switches on latch side of doors. Locate disconnect devices in mechanical and elevator machine rooms on latch side of door.

9.3 Mounting Heights

- .1 Mounting height of equipment is from finished floor to centreline of equipment unless specified or indicated otherwise.
- .2 If mounting height of equipment is not specified or indicated, verify before proceeding with installation.
- .3 For Barrier Free areas verify the mounting heights with the authority having jurisdiction prior to rough-in.
- .4 Install wall-mounted electrical devices at elevations in accordance with the Architectural drawings. In the absence of such drawings, install at elevations in accordance with the following heights unless otherwise shown.

Description	General Area	Barrier Free
Local switches	1200 mm (47")	1050 mm (41")
Wall receptacles: General	300 mm (12")	450 mm (18")
Wall receptacles: Hospitals	450 mm (18")	450 mm (18")
Wall receptacles: above top of continuous baseboard heater	200 mm (8")	200 mm (8")
Wall receptacles: above top of counters or counter splash backs	175 mm (7")	175 mm (7")
Wall receptacles shown above top of counters where there is no counter: height above finished floor	1200 mm (47")	1050 mm (41")
Wall receptacles: In Mechanical rooms	1200 mm (47")	1050 mm (41")
Telephone outlets	300 mm (12")	450 mm (18")
Outlets for wall mounted telephones	1500 mm (59")	1000 mm (39")
Fire alarm pull stations	1500 mm (59")	1200 mm (47")
Fire alarm bells	2100 mm (83")	2100 mm (83")
Wall mounted speakers	2100 mm (83")	2100 mm (83")
Wall mounted door operator push pads	1000mm (39")	1000mm (39")
Wall or floor mounted, vertical panel type door operator controls	from ≤200mm to ≥900mm (from ≤7.9" to ≥36")	from ≤200mm to ≥900mm (from ≤7.9" to ≥36")
Television outlets	300 mm (12")	450 mm (18")
Clocks	2100 mm (83")	2100 mm (83")
Other controls	1200 mm (47")	1050 mm (41")
Panelboards	As required by code or as indicated	As required by code or as indicated

9.4 Conduit and Cable Installation

- .1 Install embedded conduit prior to pouring of concrete.

- .2 Arrange for holes through exterior walls and roof to be flashed and made weatherproof under Division 7.
- .3 Install cables, conduits and fittings to be embedded or plastered over, neatly and close to building structure so furring can be kept to minimum.
- .4 Supply and deliver inserts to site in ample time to be built into work of other trades. Provide necessary templates and adequate instructions and assistance to locate and install inserts.
- .5 Secure inserts firmly to form work before concrete is poured.
- .6 Provide insert drawings as required.

9.5 Plywood Backboards

- .1 Provide plywood backboards in electrical and telecommunications rooms and closets where indicated or specified for mounting of equipment.
 - .2 Plywood to be securely attached to the building structure.
 - .3 Plywood to be 19mm, void free, good one side, mounted with good side exposed.
- Plywood to be Class A fire retardant, FSC certified and contain no added urea formaldehyde.

END OF SECTION

PAINTING FOR ELECTRICAL SERVICES

26 05 02

1 GENERAL

1.1 Scope

- .1 Provide industrial sealer and anti-corrosion coatings for electrical building services and related construction elements including:
 - .1 electrical services and supporting elements as specified under other sections of Divisions 26 to 28,
 - .2 concrete curbs, housekeeping pads, floor trenches and electrical containment floor areas,
- .2 General painting of service room floors and decorative finish painting of building services is provided under Division 09.

1.2 Applicable Codes and Standards

- .1 Legislation:
 - .1 SOR/2009-264 Canadian Environmental Protection Act, *Volatile Organic Compound (VOC) Concentration Limits for Architectural Coatings Regulations*
- .2 Installation standards and codes:
 - .1 LEED v4 New Construction, credit EQ Cr 4.2
 - .2 SSPC Society for Protective Coatings, Surface Preparation Standards
- .3 Product standards:
 - .1 Green Guard GC-03 Green Seal Environmental Criteria for Anti-Corrosion Paints

1.3 Submittals

- .1 Submit product data sheets which demonstrate compliance with LEED VOC requirements.

2 PRODUCTS

2.1 Industrial Anti-Corrosion Coatings – Carbon Steel Materials

- .1 Outdoor applications:
 - .1 top coat: industrial urethane alkyd enamel top coat, or single compound 100% acrylic coating,
 - .2 primer coat: as per manufacturers' recommendation for coating of steel piping,
 - .3 colour: Sherwin Williams No SW4027 (Galvano), unless specified elsewhere,
 - .4 VOC limit: 340 g/L of product less water and excluded compounds.

Standard of Acceptance

- Sherwin Williams – Pro Industrial Urethane Alkyd Enamel
- Sherwin Williams – Pro Industrial Acrylic

- .2 Indoor applications:
 - .1 top coat: single compound 100% acrylic coating,
 - .2 primer coat: as per manufacturers' recommendation for coating of steel piping,
 - .3 colour: Sherwin Williams No SW4027 (Galvano), unless specified elsewhere,

- .4 LEED: certified to Green Guard standard GC-03 for anti-corrosion coatings,
- .5 VOC limit: 250 g/L of product less water, U.S. EPA method 24.

Standard of Acceptance

- Sherwin Williams – Pro Industrial Acrylic

- .3 Zinc rich primer applications for field painting of carbon steel material, or touch-up of galvanized steel material:

- .1 top coat: as specified for interior or exterior applications,
- .2 primer: single or multi-part zinc rich coating,
- .3 colour: gray-green,
- .4 LEED compliance: certified to Green Guard standard GC-03 for anti-corrosion coatings,
- .5 VOC limit: 250 g/L of product less water, U.S. EPA method 24.

Standard of Acceptance

- Sherwin Williams – Zinc Clad III HS 100

2.2 Industrial Coatings – Poured Concrete

- .1 For field painting of concrete floor trenches, housekeeping pads, and curbs in service rooms:
 - .1 resistant to fuel oil, general solvents and water,
 - .2 top coat: water based urethane floor enamel,
 - .3 primer coat: water based epoxy,
 - .4 colour: Sherwin Williams Deck Gray,
 - .5 colour: Sherwin Williams Safety Yellow where shown,
 - .6 VOC limit: 250 g/L of product less water, U.S. EPA method 24.

Standard of Acceptance

- Sherwin Williams – Armorseal Floor Plex 7100 Primer / Amorseal 1K Topcoat

3 EXECUTION

3.1 General

- .1 Refer to requirements for services to be painted in the relevant sections of Division 26 to 28 and as follows.
- .2 Touch up any damage to factory prime coat resulting from shipping or installation with appropriate primer for indoor/outdoor installation with appropriate top coat, of colour to match existing. Materials to be compatible with the original factory finish.
- .3 Touch up any damage to factory galvanized finish resulting from site welding, shipping or installation with zinc rich primer.

3.2 Installation

- .1 Surface preparation
 - .1 Clean surfaces to be painted in accordance with paint manufacturer recommendations and as follows.

- .2 Surfaces to be clean, dry and free from dust, oil, grease, loose or flaking paint and foreign materials at time of application of paint materials.
 - .3 For carbon steel materials, remove all loose mill scale, loose rust, loose paint, and other loose detrimental foreign matter by hand chipping, scraping, sanding, and wire brushing in accordance with SSPC-SP2 Hand Tool Cleaning.
 - .4 For galvanized steel material, solvent clean to SSPC-SP1 Solvent Cleaning. If galvanized surface is already rusty, remove loose rust and dirt in accordance with SSPC-SP2 and prime the exposed metal the same day as being cleaned.
 - .5 For concrete materials, clean surfaces to SSPC-SP13/NACE 13 by mechanical, chemical or thermal methods.
 - .6 Tape-off adjacent materials which are not to be painted. Provide drop sheets to protect other surfaces from falling paint or over-spray.
- .2 Application - General
- .1 Apply one coat of primer to metal items, with exception of galvanized or concrete encased items.
 - .2 Use primer unadulterated, as prepared by manufacturer.
 - .3 Apply top coat in the number of coats recommended by the manufacturer, to obtain 100% coverage to the minimum recommended thickness, free of streaks, drips and sags.
 - .4 Do not paint when temperature is lower than 7°C.
- .3 Application – Galvanized base metal finish
- .1 Where material is galvanized, touch up welded sections or other locations where protective galvanized surface has been damaged, with zinc rich primer.
 - .2 Apply a top coat to match base material colour.
- .4 Application – Concrete trenches, housekeeping pads, curbs:
- .5 Apply one coat of primer and two top-coats.
- .1 After paint has dried, seal joints between curbs and floors with a silicone based industrial caulking in matching colour.

End of Section

LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS

26 05 19

1 GENERAL

1.1 Scope

- .1 Provide wires and cables for systems operating between 0 and 1000 Volts, including:
 - .1 building wires,
 - .2 armoured cables,
 - .3 aluminium sheathed cables,
 - .4 mineral insulated cables including fire rated cables,
 - .5 instrumentation and control cabling.

1.2 Related Sections

- .1 Without limiting the scope of work or applicability of other specification sections, the work under this section directly integrates with or refers to the following specification sections:
 - .1 26 05 33 Conduits, Fastenings and Fittings
 - .2 26 05 37 Wireways and Auxiliary Gutters
 - .3 26 27 28 Wire and Box Connectors - 0 - 1000 V

1.3 Applicable Codes and Standards

- .1 Product standards:
 - .1 CSA C22.2 No. 38 Thermoset-Insulated Wires and Cables
 - .2 CSA C22.2 No. 51 Armoured Cables
 - .3 CSA C22.2 No. 94.1 Enclosures for Electrical Equipment, Non-Environmental Considerations
 - .4 CSA C22.2 No. 123 Metal Sheathed Cables
 - .5 CSA C22.2 No. 124 Mineral-Insulated Cables
 - .6 CSA C22.2 No. 131 Type TECK 90 Cable
 - .7 CSA C22.2 No. 239 Control and Instrumentation Cables
 - .8 ULC S139 Standard for Fire Test for Circuit Integrity of Fire-Resistive Power, Instrumentation, Control, and Data Cables

1.4 Design Criteria

- .1 Conductor sizes are based on connected equipment having a temperature marking of 75°C or higher. Where equipment does not have a temperature marking or it has a marking lower than 75°C, increase the size of the conductors accordingly, to the satisfaction of the consultant.
- .2 For wires in conduit, conductor sizes are based on not more than 3 current carrying conductors in a conduit. Where more than 3 current carrying conductors are installed in a conduit increase the conductor size accordingly, to the satisfaction of the consultant.
- .3 Do not reduce conductor sizes, conductors may have been oversized due to voltage drop constraints.

1.5 Submittals

- .1 Submit product data sheets for materials specified herein.

2 PRODUCTS

2.1 Building Wires

- .1 Conductors: copper conductors: size as indicated.
- .2 Minimum wire size: No. 12 AWG.
- .3 Stranded conductors for 10 AWG and larger.
- .4 Insulation:
 - .1 chemically cross-linked thermosetting polyethylene material,
 - .2 RW90 or RWU90 to CSA C22.2 No. 38,
 - .3 1000V and 600V ratings.
- .5 Conductors to be colour coded. Conductors to have colour impregnated into insulation at time of manufacture. Phase conductors No. 8 AWG and larger, with black insulation, may be colour coded with adhesive colour coding tape.

Standard of Acceptance

- Aetna Insulated Wire
- General Cable
- Nexans Canada Inc.
- Prysmian Cables & Systems Ltd.
- Southwire

2.2 Armoured Cables

- .1 Type: AC90, 600V 90C to CSA C22.2 No. 51, FT4 rated.
- .2 Conductors:
 - .1 copper, minimum size #12,
 - .2 bare copper bonding wire sized per the electrical code.
- .3 Insulation: RW90 XLPE.
- .4 Armour: interlocking type fabricated from galvanized steel or aluminum strip.

2.3 Armoured Cables with Insulated Bonding Conductor

- .1 Type: AC90 ISO-BX, 600V 90C to CSA C22.2 No. 51, FT4 rated.
- .2 Conductors:
 - .1 copper, minimum size #12,
 - .2 green insulated copper bonding wire, same size as the phase conductors.
- .3 Insulation: RW90 XLPE.
- .4 Armour: interlocking type fabricated from galvanized steel or aluminum strip.

2.4 Aluminum Sheathed Cables

- .1 Type: RA90, 600V to CSA C22.2 No. 123.

- .2 Conductors: insulated copper, quantity and size as indicated.
- .3 Insulation: RW90 XLPE.
- .4 Sheath: corrugated aluminum.
- .5 Jacket: FT-4 rating with rating permanently identified on jacket.
- .6 Connectors:
 - .1 watertight,
 - .2 non-magnetic for single conductor cables.

2.5 Armoured Cables ACWU

- .1 Type: ACWU90, 600V to CSA C22.2 No. 51.
- .2 Conductors: insulated copper, quantity and size as indicated.
- .3 Insulation: RW90 XLPE.
- .4 Armour: interlocking aluminum.
- .5 Bonding conductor:
 - .1 bare in multiconductor cables,
 - .2 bare concentric in single conductor cables,
 - .3 copper or same material as phase conductors.
- .6 Jacket: FT-4 rating with rating permanently identified on jacket.
- .7 Connectors:
 - .1 Watertight.
 - .2 Non-magnetic for single conductor cables.

2.6 Armoured Cables Teck

- .1 Type: TECK90, 600V to CSA C22.2 No. 131.
- .2 Conductors: insulated copper, quantity and size as indicated.
- .3 Insulation: RW90 XLPE.
- .4 Inner jacket; FT-4 rated PVC.
- .5 Armour: interlocking aluminum.
- .6 Bonding conductor:
 - .1 bare in multiconductor cables,
 - .2 bare concentric in single conductor cables,
 - .3 same material as phase conductors,
 - .4 copper for feeders serving patient care areas,
 - .5 isolated from the armour by the inner jacket.
- .7 Outer jacket: FT-4 rating with rating permanently identified on jacket.
- .8 Connectors:
 - .1 Watertight,
 - .2 Equal to T&B Star Teck type,
 - .3 Non-magnetic connectors for single conductor cables.

Standard of Acceptance (armoured, aluminium sheathed and TECK cables)

- Aetna Insulated Wire
- General Cable
- Nexans Canada Inc.
- Northern Cables Inc.
- Prysmian Cables & Systems Ltd.
- Southwire

2.7 Mineral Insulated Cable

- .1 Type: MI, 600V to CSA C22.2 No. 124.
- .2 Conductors: solid annealed copper, quantity and size as indicated.
- .3 Insulation: compacted magnesium oxide.
- .4 Sheath: seamless annealed copper.
- .5 Terminations: as supplied by the cable manufacturer.
- .6 Cables to be shipped with ends sealed.

Standard of Acceptance

- Pentair/Pyrotenax System 500

2.8 Fire Rated Mineral Insulated Cable

- .1 Type: MI, 600V to CSA C22.2 No. 124.
- .2 Conductors: solid annealed copper, quantity and size as indicated.
- .3 Insulation: compacted magnesium oxide.
- .4 Sheath: seamless annealed copper.
- .5 Terminations: as supplied by the cable manufacturer.
- .6 Fire rating: listed 2 hour rating to ULC S139, cables labelled accordingly.
- .7 Cables to be shipped with ends sealed.

Standard of Acceptance

- Pentair/Pyrotenax System 1850

2.9 Instrumentation and Control Cabling

- .1 Control cables to CSA C22.2 NO. 239.
- .2 Control cables as follows:

Conductors	Quantity, arrangement and gauge shown on drawings or specified elsewhere.
Identification	Colour coded or numbered.
Insulation	XLPE
Armour	Steel (No armour required if installed in conduit or approved wireway).

Jacket	FT4 Flame Retardant, FT6 when installed in open style cable trays in ceiling spaces that are used as return air plenums.
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- .3 Shielded cables to provide 100% shield coverage complete with drain wire.
- .4 Multipair twisted shielded cables to have individually shielded pairs, overall shield, drain wires and overall rated jacket.

Standard of Acceptance

- General Cable (Carol)
- Belden
- Nexans Canada Inc.

3 EXECUTION

3.1 General

- .1 Conductor colour coding to be as follows:
 - .1 Phase A - Red
 - .2 Phase B - Black
 - .3 Phase C - Blue
 - .4 Neutral - White
 - .5 Ground - Green
 - .6 Control - Orange
- .2 Where colour coding tape is utilized, apply at least 50 mm (2") at terminations, junction boxes and pull boxes. Do not paint conductors.
- .3 Use:
 - .1 1000 V insulation for 600 Volt systems,
 - .2 600 V insulation for 347/600 V and 120/208 V systems.
- .4 Wiring installed underground: RWU90.
- .5 Wiring in channel back of luminaires:
 - .1 600 volt type GTF or TEW,
 - .2 temperature rating as required by CSA and/or manufacturer requirements.
- .6 Store wire and cable in a clean, dry, well ventilated area.
- .7 Protect white insulated wire from exposure to NOx gas (eg: exhaust from propane fuelled equipment) by wrapping with shrink wrap, by locating away from sources of NOx and by maintaining adequate ventilation to minimize NOx levels.
- .8 Where white insulated wire has discoloured:
 - .1 do not install,
 - .2 dispose of the wire,
 - .3 remove and replace wire that has been installed.
- .9 Neatly train circuit wiring in cabinets, panels, pullboxes and junction boxes and hold with nylon cable ties.

- .10 Splice wires:
 - .1 up to and including No. 6 AWG: with nylon insulated expandable spring type connectors with moulded thermoplastic body and expandable square edge design spring.
 - .2 larger than #6 AWG: with compression sleeve connectors and heat shrink insulating sleeves, voltage rating of sleeves equal to or greater than the cable.
 - .3 aluminum Conductors: with long barrel compression sleeve connectors approved for use with aluminum conductors and heat shrink insulating sleeves, voltage rating of sleeves equal to or greater than the cable.
- .11 Do not splice conductors used in parallel runs.
- .12 Where the Consultant agrees that splicing of conductors in a parallel run is unavoidable, connect the paralleled runs of the feeder together in a junction box at the splice location, using:
 - .1 copper bus bars of quantity and size to match the circuit,
 - .2 a two hole long barrel compression lug on each cable,
 - .3 two nuts and bolts on each lug,
 - .4 two oversized flat washers and a spring lock washer, or two Belleville washers, on each bolt,
 - .5 an oversized enclosure to house the above; CSA 22.2 No 94.1 Type 1.

3.2 Installation of Building Wires

- .1 Install wiring as follows:
 - .1 in conduit systems in accordance with Section 26 05 33.
 - .2 in wireways and auxiliary gutters in accordance with Section 26 05 37.
- .2 Home runs, of 15 and 20 Ampere circuits to lighting and receptacle panels, which exceed:
 - .1 25 m (75') in length: No. 10 AWG or larger,
 - .2 40 m (120') in length: No. 8 AWG or larger,
 - .3 60 m (180') in length: No. 6 AWG or larger.
- .3 Increase the size of branch circuit conductors and home runs as required so that the total voltage drop, from panelboards to loads, does not exceed 3% under load.
- .4 For branch circuit wiring a common neutral conductor may be used with two or three phase conductors except where indicated otherwise.
- .5 For branch wiring, common neutral conductors may be used in the following applications:
 - .1 lighting circuits, excluding dimming circuits,
 - .2 housekeeping receptacles,
 - .3 specific purpose receptacles for equipment that does not produce harmonic currents, such as resistance heating.
- .6 Where wires are damaged or contaminated during installation, remove and dispose of wires, swab out conduits and pull in new, clean conductors.

3.3 Installation of Armoured Cables AC90(BX)

- .1 May be used for drops to surface and recessed mounted fluorescent luminaires.
- .2 Do not use in patient care areas.
- .3 Terminate cables in accordance with Section 26 27 28.

3.4 Installation of Armoured Cables AC90 ISO-BX

- .1 May be used for drops to surface and recessed mounted fluorescent luminaires in patient care areas.
- .2 May be used for wiring to outlets, receptacles and light switches in patient care areas, provided that the wiring is concealed within walls and that horizontal runs within the ceiling space do not exceed 3m.
- .3 May be used for wiring to isolated ground receptacles, provided that the wiring is concealed within walls and that horizontal runs within the ceiling space do not exceed 3m.
- .4 Terminate cables in accordance with Section 26 27 28.

3.5 Installation of Aluminum Sheathed Cables

- .1 Install and terminate cables in accordance with manufacturer's recommendations.
- .2 Use non-magnetic connectors for single conductor cables.
- .3 For single conductor cables in free air circuits rated up to and including 400Amperes:
 - .1 Space cables one cable diameter apart throughout the run.
 - .2 Cut an opening in the enclosure at each end of the run, opening to be large enough for all cables of the circuit to pass through with spacings maintained.
 - .3 Provide a 6mm thick aluminium termination plate at each end of the run.
 - .4 Size the termination plates to overlap the openings by at least 20mm on all sides.
 - .5 Seal the plates to the enclosures with silicone sealant and secure to the enclosures with nuts, bolts and lock washers every 150mm.
 - .6 Terminate all cables of the circuit on the same terminal plate.
 - .7 Bond each aluminium termination plate to its associated enclosure.
- .4 For single conductor cables in free air circuits rated greater than 400Amperes:
 - .1 Space cables one cable diameter apart throughout the run.
 - .2 Cut an opening in the enclosure at each end of the run, opening to be large enough for all cables of the circuit to pass through with spacings maintained.
 - .3 At the supply end of the run:
 - (a) provide a 6mm thick aluminium termination plate,
 - (b) size the termination plate to overlap the opening by at least 20mm on all sides,
 - (c) seal the plate to the enclosure with silicone sealant and secure to the enclosure with nuts, bolts and lock washers every 150mm,
 - (d) terminate all cables of the circuit on the terminal plate,
 - (e) bond the aluminium termination plate to the enclosure.
 - .4 At the load end of the run:
 - (a) provide a 6mm thick non-conductive fire-resistant FRP (Glastic) termination panel,
 - (b) size the termination panel to overlap the opening by at least 20mm on all sides,
 - (c) seal the panel to the enclosure with silicone sealant and secure to the enclosure with nuts, bolts and lock washers every 150mm,
 - (d) terminate all cables of the circuit on the terminal panel,
 - (e) ensure that the cable connectors do not make electrical contact with the enclosure.
 - .5 Install a separate bonding conductor for the circuit:
 - (a) of copper wire,

- (b) sized per the Electrical Safety Code,
 - (c) run from the bonding lug or bus in the supply end enclosure to the bonding lug or bus in the load end enclosure,
 - (d) separated from the phase cables throughout the run, by a distance of not less than the spacing between the phase cables,
 - (e) securely fastened throughout the run.
- .5 For single conductor cables in direct buried circuits:
- .1 Space cables apart per Diagram B4-1 of the electrical code.
 - .2 Maintain cable spacing throughout the run.
 - .3 Cut an opening in the enclosure at each end of the run, opening to be large enough for all cables of the circuit to pass through with spacings of not less than one cable diameter.
 - .4 At the supply end of the run:
 - (a) provide a 6mm thick aluminium termination plate,
 - (b) size the termination plate to overlap the opening by at least 20mm on all sides,
 - (c) seal the plate to the enclosure with silicone sealant and secure to the enclosure with nuts, bolts and lock washers every 150mm,
 - (d) terminate all cables of the circuit on the terminal plate,
 - (e) bond the aluminium termination plate to the enclosure.
 - .5 At the load end of the run:
 - (a) provide a 6mm thick non-conductive fire-resistant FRP (Glastic) termination panel,
 - (b) size the termination panel to overlap the opening by at least 20mm on all sides,
 - (c) seal the panel to the enclosure with silicone sealant and secure to the enclosure with nuts, bolts and lock washers every 150mm,
 - (d) terminate all cables of the circuit on the terminal panel,
 - (e) ensure that the cable connectors do not make electrical contact with the enclosure.
 - .6 Install a separate bonding conductor for the circuit:
 - (a) insulated RWU90 copper,
 - (b) sized per the Electrical Safety Code,
 - (c) run from the bonding lug or bus in the supply end enclosure to the bonding lug or bus in the load end enclosure,
 - (d) separated from the phase cables throughout the run, by a distance of not less than the spacing between the phase cables.

3.6 Installation of Armoured Cables ACWU and TECK

- .1 Install and terminate cables in accordance with manufacturer's recommendations.
- .2 Use non-magnetic connectors for single conductor cables.
- .3 For single conductor cables in free air circuits rated up to and including 400Amperes:
 - .1 Space cables one cable diameter apart throughout the run.
 - .2 Cut an opening in the enclosure at each end of the run, opening to be large enough for all cables of the circuit to pass through with spacings maintained.
 - .3 Provide a 6mm thick aluminium termination plate at each end of the run.
 - .4 Size the termination plates to overlap the openings by at least 20mm on all sides.

- .5 Seal the plates to the enclosures with silicone sealant and secure to the enclosures with nuts, bolts and lock washers every 150mm.
- .6 Terminate all cables of the circuit on the same terminal plate.
- .7 Connect the cable bonding conductors to the enclosure bonding lug or bus at each end of the run.
- .8 Bond each aluminium termination plate to its associated enclosure.
- .4 For single conductor cables in free air circuits rated greater than 400Amperes:
 - .1 Space cables one cable diameter apart throughout the run.
 - .2 Cut an opening in the enclosure at each end of the run, opening to be large enough for all cables of the circuit to pass through with spacings maintained.
 - .3 At the supply end of the run:
 - (a) provide a 6mm thick aluminium termination plate,
 - (b) size the termination plate to overlap the opening by at least 20mm on all sides,
 - (c) seal the plate to the enclosure with silicone sealant and secure to the enclosure with nuts, bolts and lock washers every 150mm,
 - (d) terminate all cables of the circuit on the terminal plate,
 - (e) connect the cable bonding conductors to the enclosure bonding lug or bus,
 - (f) bond the aluminium termination plate to the enclosure.
 - .4 At the load end of the run:
 - (a) provide a 6mm thick non-conductive fire-resistant FRP (Glastic) termination panel,
 - (b) size the termination panel to overlap the opening by at least 20mm on all sides,
 - (c) seal the panel to the enclosure with silicone sealant and secure to the enclosure with nuts, bolts and lock washers every 150mm,
 - (d) terminate all cables of the circuit on the terminal panel,
 - (e) cut off the cable bonding conductors at the connector and cover with insulating tape, ensure that the cable bonding conductors do not make any electrical contact.
 - (f) ensure that the cable connectors do not make electrical contact with the enclosure.
 - .5 Install a separate bonding conductor for the circuit:
 - (a) of copper wire,
 - (b) sized per the Electrical Safety Code,
 - (c) run from the bonding lug or bus in the supply end enclosure to the bonding lug or bus in the load end enclosure,
 - (d) separated from the phase cables throughout the run, by a distance of not less than the spacing between the phase cables,
 - (e) securely fastened throughout the run.
- .5 For single conductor cables in direct buried circuits:
 - .1 Space cables apart per Diagram D8 of the electrical code.
 - .2 Maintain cable spacing throughout the run.
 - .3 Cut an opening in the enclosure at each end of the run, opening to be large enough for all cables of the circuit to pass through with spacings of not less than one cable diameter.
 - .4 At the supply end of the run:
 - (a) provide a 6mm thick aluminium termination plate,
 - (b) size the termination plate to overlap the opening by at least 20mm on all sides,

- (c) seal the plate to the enclosure with silicone sealant and secure to the enclosure with nuts, bolts and lock washers every 150mm,
 - (d) terminate all cables of the circuit on the terminal plate,
 - (e) connect the cable bonding conductors to the enclosure bonding lug or bus,
 - (f) bond the aluminium termination plate to the enclosure.
- .5 At the load end of the run:
- (a) provide a 6mm thick non-conductive fire-resistant FRP (Glastic) termination panel,
 - (b) size the termination panel to overlap the opening by at least 20mm on all sides,
 - (c) seal the panel to the enclosure with silicone sealant and secure to the enclosure with nuts, bolts and lock washers every 150mm,
 - (d) terminate all cables of the circuit on the terminal panel,
 - (e) cut off the cable bonding conductors at the connector and cover with insulating tape, ensure that the cable bonding conductors do not make any electrical contact,
 - (f) ensure that the cable connectors do not make electrical contact with the enclosure.
- .6 Install a separate bonding conductor for the circuit:
- (a) insulated RWU90 copper,
 - (b) sized per the Electrical Safety Code,
 - (c) run from the bonding lug or bus in the supply end enclosure to the bonding lug or bus in the load end enclosure,
 - (d) separated from the phase cables throughout the run, by a distance of not less than the spacing between the phase cables.

3.7 Installation of Mineral Insulated Cables

- .1 Provide fire rated mineral insulated cables unless non-fire rated cables are indicated.
- .2 Store cables under dry conditions.
- .3 Handle cables with care to avoid cable kinks; it is recommended that cable be uncoiled from supply reel by rolling. Do not install kinked cables.
- .4 Install and terminate cables in accordance with the manufacturer's recommendations.
- .5 Install fire rated cables in accordance with ULC S139 and in accordance with the manufacturer's recommendations.
- .6 Install cables in trays, on hangers or on channels secured to walls, beams or floor slabs, using clamps supplied by or recommended by the manufacturer.
- .7 For cable tray installations:
 - .1 install fire rated cables in stainless steel trays only,
 - .2 non fire rated cables may be installed in galvanized, aluminium, fibreglass or stainless steel trays.
- .8 Support cables with clamps, straps, clips of:
 - .1 copper,
 - .2 stainless steel,
 - .3 steel material,
 - .4 aluminum, for non fire rated cables only.

- .9 Secure cables so that they cannot contact any dissimilar metals other than the approved supporting materials.
- .10 In damp or wet areas wrap cables with electrical tape where the cable contacts the supporting materials unless the supporting materials are copper or stainless steel. For non-fire rated cables only, clamps with integral rubber insets may be used in lieu of tape.
- .11 Support fire rated cables:
 - .1 directly from fire rated structure per ULC FHITC.1850 or, where ULC FHITC.1850 cannot be applied, support cables in accordance with written instructions from the Consultant,
 - .2 on centres not exceeding:
 - (a) 1219 mm (4') for cables less than or equal to 7.6mm (0.3") in diameter,
 - (b) 1828 mm (6') for cables greater than 7.6mm (0.3") in diameter,
 - .3 with stainless steel clamps or straps on cable groups midway between supports, for single conductor cables.
- .12 For non-fire rated cables provide supports on centres not exceeding 2000mm (6.56').
- .13 Bend cables using a suitable hickey with a bending radius of not less than six times the cable diameter.
- .14 Protect embedded cables from punctures and mechanical damage.
- .15 For unjacketed single conductor cables that form a circuit or form one run of a feeder with parallel runs, install the cables with their sheaths in contact with one another throughout their length, excluding 1m at each point of connection to equipment or box.
- .16 For single conductor cables in circuits rated 200 A and higher:
 - .1 Cut an opening in the enclosure at each end of the run, opening to be large enough for all cables of the circuit to pass through with spacings maintained.
 - .2 Provide a 6mm thick brass termination plate at each end of the run.
 - .3 Size the termination plates to overlap the openings by at least 20mm on all sides.
 - .4 Seal the plates to the enclosures with silicone sealant and secure to the enclosures with nuts, bolts and lock washers every 150mm.
 - .5 Terminate all cables of the circuit on the same termination plate.
 - .6 Provide a copper bonding conductor, sized per Table 16 of the ESC, from each brass termination plate to the equipment ground lug or bus in the associated enclosure.
 - .7 Connect to the termination plate and to the equipment ground lug or bus using Burndy YA compression connectors with 12mm stainless steel bolts and matching hardware.
- .17 For parallel runs, install cable groups at least 2.15 cable diameters apart.
- .18 Terminate cables using glands and seals as supplied by the cable manufacturer. Install gland and seal assemblies using tools specifically designed for the purpose.
- .19 For fire rated feeders to fire pump controllers:
 - .1 terminate the mineral insulated cable in a type 3R junction box located adjacent to the fire pump controller,
 - .2 extend the feeder using RW90 in EMT, sized to match the ampacity rating of the mineral insulated cables,
 - .3 connect the EMT to the bottom of the fire pump controller enclosure, do not connect to the top or sides of the controller enclosure.

- .20 Upon completion of cable terminations and prior to energization, test the insulation resistance of each cable with an insulation tester. Where measured values are not acceptable to the Consultant, rework or replace the cable until satisfactory results are obtained.
- .21 For fire rated cables, provide the services of the cable manufacturer to inspect the cable installation and termination methods and provide a written report documenting that the cables have been installed in accordance with the requirements of the ULC standard and the ULC listing and in accordance with the manufacturer's recommendations. Submit the report to the Consultant.

3.8 Installation of Instrumentation, Communication and Control Cabling

- .1 Install wiring as follows:
 - .1 in conduit systems in accordance with Section 26 05 33,
 - .2 in wireways and auxiliary gutters in accordance with Section 26 05 37,
 - .3 in open style cable trays in ceiling spaces, using FT6 plenum rated cable assemblies,
 - .4 in open style cable trays in ceiling spaces, using FT6 or FT4 rated cable where the ceiling space is not used as a return air plenum, as directed by the Consultant.
- .2 Neatly train circuit wiring in cabinets, panels, pullboxes and junction boxes and hold with nylon cable ties.
- .3 Run instrumentation, communication and control cabling point to point and terminate on terminal strips. Do not splice communication or control cabling. Where long runs make a continuous point to point installation impractical, make splices on labelled terminal blocks in an accessible labelled terminal cabinet, installed at 1200 mm (48") above floor, and indicate cabinet location, terminal and wire numbers on the As-built drawings.
- .4 Terminate control cables in equipment with suitable connectors.
- .5 Clearly identify cables at both ends, with permanent PVC wire markers, Weiland type Z or equal, indicating cable number and wire numbers.

END OF SECTION

SECONDARY GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

26 05 26.16

1 GENERAL

1.1 Scope

- .1 Provide grounding and bonding for electrical distribution at 750 V and lower, as shown.

1.2 Related Sections

- .1 Without limiting the scope of work or applicability of other specification sections, the work under this section directly integrates with or refers to the following specification sections:
 - .1 26 01 01 Electrical General Requirements.
 - .2 26 05 53 Identification for Electrical Systems.
 - .3 26 08 05 System Co-ordination, Verification and Testing.

1.3 Applicable Codes and Standards

- .1 Installation codes and standards:
 - .1 ANSI/IEEE 142 IEEE Recommended Practice for Grounding of Industrial and Commercial Power Systems
 - .2 ANSI/IEEE 837 Standard for Qualifying Permanent Connections Used in Substation Grounding.
 - .3 ANSI/TIA 568A General Telecommunications Cabling for Customer Premises
 - .4 ANSI/TIA 569 Telecommunications Pathways and Spaces
 - .5 ANSI/TIA 607 General Telecommunications Bonding and Grounding (Earthing) for Customer Premises
 - .6 CSA-Z32 Electrical Safety and Essential Electrical Systems in Health Care Facilities.
- .2 Product standards:
 - .1 CSA C22.2 No 41 Grounding and Bonding Equipment.

1.4 Submittals

- .1 Submit product data sheets for materials specified herein.
- .2 Submit list of nameplates.
- .3 Operation and Maintenance Data:
 - .1 Provide operation and maintenance data for incorporation into operating and maintenance manuals.

2 PRODUCTS

2.1 Clamps

- .1 Conductor to water main clamps suitable for grounding connections,
- .2 Type and size as required to make electrically conductive connections to underground water pipe,
- .3 Non-corroding copper, bronze and/or stainless steel construction.

2.2 Electrodes

- .1 Rod electrodes:
 - .1 material: steel with a bonded copper cladding not less than 254 µm (10 mils) thick,
 - .2 size: 19 mm dia by 3 m long ($\frac{3}{4}$ " dia by 10' long),
 - .3 listed to C22.2 No 41.
- .2 Plate Electrodes:
 - .1 material: copper,
 - .2 size: 600 x 600,
 - .3 thickness: 3.2 mm,
 - .4 listed to C22.2 No 41.

2.3 Conductors

- .1 Buried grounding conductors:
 - .1 bare, stranded, tinned, soft annealed copper,
 - .2 size #4/0 AWG unless indicated otherwise.
- .2 Insulated grounding and bonding conductors:
 - .1 bare, stranded, soft annealed copper,
 - .2 type RW90 green insulation.

2.4 Accessories

- .1 Accessories including but not limited to:
 - .1 grounding and bonding bushings,
 - .2 protective type clamps,
 - .3 bolted type conductor connectors,
 - .4 exothermic welded type conductor connectors,
 - .5 bonding jumpers, straps,
 - .6 pressure wire connectors,to be of non-corroding copper, bronze and/or stainless steel construction.

2.5 Perimeter Ground Bus

- .1 Bus:
 - .1 6 mm x 38 mm ($\frac{1}{4}$ " x $1\frac{1}{2}$ ")copper,
 - .2 mounted 150 mm (6") above floor,
 - .3 mounted on insulated spacers 600 mm (24") on centre.
- .2 Mounting spacers:
 - .1 stand off insulators to UL 891,
 - .2 25 to 32 mm high waterproof glass fibre reinforced polyamide,
 - .3 750V insulated,
 - .4 UL 94VO self extinguishing,
 - .5 bichromated zinc plated threaded steel inserts.

Standard of Acceptance

- Erico ISO I series c/w insulator mounting kits

2.6 Raised Floor Bonding

- .1 Communication and computer room raised floor ground clamps:

Standard of Acceptance

- Burndy - fig. Uniground.

3 EXECUTION

3.1 Installation

- .1 Ground electrical systems in accordance with the Electrical Safety Code and the latest edition of ANSI/IEEE Standard 142.
- .2 Bond electrical equipment in accordance with the Electrical Safety Code and the latest edition of ANSI/IEEE Standard 142.
- .3 Install connectors in accordance with manufacturer's instructions.
- .4 Protect exposed grounding and bonding conductors from mechanical injury.
- .5 Make buried connections, and connections to conductive water main and electrodes, using copper welding by exothermic process.
- .6 Use mechanical connectors for grounding and bonding connections to equipment provided with lugs.
- .7 Soldered joints not permitted.
- .8 Provide a bonding wire for flexible conduit, connected at both ends to bonding bushing, solderless lug, clamp or cup washer and screw. Neatly cleat bonding wire to exterior of flexible conduit.
- .9 Provide a separate bonding conductor in each conduit:
 - .1 sized as per Table 16 of the ESC,
 - .2 not less than #12 AWG copper,
 - .3 with one bond conductor for every three line conductors.
- .10 Bond building structural steel and metal siding to ground by welding copper to steel.
- .11 Make grounding connections in radial configuration only, with connections terminating at a single grounding point. Avoid loop connections.
- .12 Install grounding conductors outside electrical rooms and electrical closets in PVC conduit and conceal where possible. Where PVC conduit is not permitted use EMT and bond the EMT to the conductor at both ends.

3.2 Electrodes

- .1 Make ground connections to continuously conductive underground water pipe on street side of water meter.
- .2 Provide a 4/0 AWG copper water meter shunt.
- .3 Install rodelectrodes and make grounding connections.
- .4 Bond grounding electrodes together with 4/0 AWG copper conductors.
- .5 For main electrical rooms on grade, provide a rod electrode at each corner of the room and connect to perimeter ground bus.
- .6 For main electrical rooms on a suspended slab, provide:

- .1 two runs of 4/0 AWG copper conductor,
- .2 connect runs to opposite corners of the perimeter ground bus,
- .3 install in PVC conduit,
- .4 run via separate routes,
- .5 connect to opposite corners of the building ground grid.
- .7 Where high resistivity soil conditions exist such as rock or sand, provide:
 - .1 additional electrodes,
 - .2 deeper electrodes,
 - .3 soil enhancement material or,
 - .4 chemically filled grounding rods,as required to achieve an acceptable resistance to ground value.

3.3 System Grounding

- .1 Provide system grounding connections to neutral point of secondary systems using not less than #6 copper conductor unless indicated otherwise.
- .2 Install insulated copper grounding conductor for service raceways and service equipment as required by the electric utility company.
- .3 Install grounding conductors in PVC conduit.

3.4 Equipment Bonding

- .1 Install insulated copper bonding connections:
 - .1 sized not less than #12 AWG and not less than indicated in Table 16 of the electrical code,
 - .2 to typical equipment including, but not necessarily limited to the following list:
 - (a) service equipment,
 - (b) transformers,
 - (c) switchboards,
 - (d) panelboards,
 - (e) splitters,
 - (f) disconnect switches,
 - (g) junction and outlet boxes,
 - (h) receptacles,
 - (i) luminaires,
 - (j) transfer switches,
 - (k) UPS systems,
 - (l) battery enclosures,
 - (m) capacitor banks,
 - (n) frames of motors,
 - (o) frames of generators (alternators),
 - (p) motor control centres,
 - (q) starters,
 - (r) fire alarm systems,

- (s) security systems,
 - (t) CCTV systems,
 - (u) audio systems,
 - (v) communications systems,
 - (w) control panels,
 - (x) outdoor lighting,
 - (y) elevators,
 - (z) other equipment that is supplied with electrical power.
- .2 Where applicable, run bonding conductors as part of the feeder.
 - .3 Where bonding conductors are run separately, install in PVC conduit.
 - .4 In healthcare facilities, for circuits to patient care receptacles, oversize the bonding conductor as necessary to comply with the voltage drop criteria in CSA standard Z32.

3.5 Communications Systems

- .1 Install bonding connections for telephone, sound, fire alarm, intercommunication systems as follows:
 - .1 telephones: make telephone bonding system in accordance with telephone company's requirements,
 - .2 communications system bonding: in accordance with ANSI/TIA 607, 568A, 569 standards,
 - .3 sound, fire alarm, intercommunication systems: as required by the electrical code except where indicated otherwise.

3.6 Bonding of Other Items

- .1 Install insulated copper bonding connections:
 - .1 sized not less than #6 AWG,
 - .2 run in PVC conduit,
 - .3 to typical items including, but not necessarily limited to following list:
 - (a) metallic water piping systems,
 - (b) metallic waste water piping systems,
 - (c) metallic gas piping systems,
 - (d) metallic vacuum piping systems,
 - (e) metallic compressed air piping systems,
 - (f) building steel work.
- .2 Review the design and installation of each piping system with the system installer and provide bonding jumpers where necessary to ensure that each piping system is electrically continuous.

3.7 Perimeter Ground Bus

- .1 Provide exposed perimeter ground bus in new electrical rooms.
- .2 Wall mount on stand off insulated spacers using zinc plated steel studs, washers, lock washers and nuts.
- .3 Connect exposed metal work in electrical roomsto perimeter ground bus with insulated stranded copper bonding conductors in PVC conduit, sized in accordance with Table 16 of the electrical code but not less than 2/0 AWG copper, except where indicated otherwise.
- .4 For switchgear lineups of four sections or more, provide at least two bonding conductors to the perimeter ground bus, one bonding conductor located at each end of the lineup.

- .5 Protect ground bus with one coat of insulating varnish.

3.8 Identification

- .1 For the grounding of each electrical system, show the location and method of grounding on the single line electrical diagrams, in accordance with Section 26 05 53.

3.9 Field Quality Control

- .1 Perform tests in accordance with:
 - .1 Section 26 01 01 - Electrical General Requirements.
 - .2 Section 26 08 05 - System Co-ordination, Verification and Testing.
- .2 Perform ground continuity and resistance tests using method appropriate to site conditions and to approval of Consultant and local authority having jurisdiction.
- .3 Perform tests before energizing electrical system.

END OF SECTION

HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

26 05 29

1 GENERAL

1.1 Scope

- .1 Provide fasteners and supports for electrical services.

1.2 Related Sections

- .1 Without limiting the scope of work or applicability of other specification sections, the work under this section directly integrates with or refers to the following specification sections:
 - .1 01 61 00 Common Product Requirements.
 - .2 26 05 01 Electrical Basic Materials and Methods

1.3 Submittals

- .1 Submit design drawings for custom fabricated trapeze hangers, sealed by a professional engineer licensed in the project location jurisdiction.
 - .1 Shop drawing details:
 - (a) construction detail drawings for each loading condition,
 - (b) span deflection calculations,
 - (c) building attachment load calculations and type.
 - .2 Provide services of engineer who sealed the custom trapeze hanger shop drawings to conduct a general review of the completed installation on site.

2 PRODUCTS

2.1 Support Channels

- .1 Hot dipped galvanized steel, U shape, size 41 mm x 41 mm x 2.5 mm (1-1/2" x 1-1.2" x 1/10") thick, surface mounted, suspended or set in poured concrete walls and ceilings.

2.2 Inserts

- .1 Inserts for conduits and raceway hangers, for single, double and multiple runs: galvanized steel.

Standard of Acceptance

- Unistrut Canada
- Burndy (Canada) Ltd. - Flexibar
- Pilgrim Technical Products Ltd. - Tufstrut

2.3 Hangers

- .1 Hangers for electrical conduit: hot-dipped galvanized after fabrication.

Standard of Acceptance

- Burndy Canada Ltd.
- Canstrut
- Electrovert Ltd.
- E. Myatt & Co. Ltd
- Steel City Electric Ltd.

- Pilgrim Technical Products Ltd.

2.4 Trapeze hangers

- .1 Performance:
 - .1 Manufactured:
 - (a) to product load listings.
 - .2 Custom fabricated:
 - (a) maximum deflection between supports: 1/250 (0.4%) of span
 - (b) minimum factor of safety : 5 times load to ultimate tensile or compressive strength.
- .2 Construction:
 - .1 Carbon steel shapes, to suit load application:
 - (a) hollow steel section,
 - (b) equal leg EI section, or
 - (c) double C channel "strong-back", with welded clips.
 - .2 Hanger rods:
 - (a) as specified above, and
 - (b) minimum two support rods,
 - (c) rods selected for minimum factor of safety of 5 times load to ultimate tensile or compressive strength of rod.
- .3 Finish:
 - .1 hot dipped galvanized finish in mechanical rooms and outdoors.
 - .2 black steel finish in other areas.

Standard of Acceptance

- Anvil Fig 45, 46, 50

3 EXECUTION

3.1 Installation

- .1 Supply and deliver inserts to site in ample time to be built into work of other trades. Provide necessary templates and adequate instructions to locate and install inserts.
- .2 Secure equipment to masonry, tile and plaster surfaces with lead anchors.
- .3 Secure equipment to poured concrete with expandable inserts.
- .4 Secure surface mounted equipment with T-bar support hanger fastened to inverted T bar ceilings. Ensure that T bars are adequately supported to carry weight of equipment specified before installation.

Standard of Acceptance

- Caddy - fig. No. 512 c/w BHC clip
- .5 Support equipment, conduit or cables using clips, spring loaded bolts, cable clamps designed as accessories to basic channel members.
- .6 Fasten exposed conduit or cables to building construction or support system using straps.

- .1 One-hole steel straps to secure surface conduits and cables 50 mm (2") and smaller.
- .2 Two-hole steel straps for conduits and cables larger than 50 mm (2").
- .3 Beam clamps to secure conduit to exposed steel work.
- .7 Suspended support systems.
 - .1 Support individual cable or conduit runs with 6 mm (¼") dia threaded rods and spring clips.
 - .2 Support 2 or more cables or conduits on channels supported by 6 mm (¼") dia threaded rod hangers where direct fastening to building construction is impractical.
- .8 For surface mounting of two or more conduits use channels.
- .9 Provide galvanized after fabrication 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 support 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 trade and approval of Consultant.
- .13 Install fastenings and supports as required for each type of equipment cables and conduits, and in accordance with manufacturer's installation recommendations.
- .14 Supply and erect special structural work required for the installation of electrical equipment. Provide anchor bolts and fastenings unless noted otherwise. Mount equipment required to be suspended above floor level, where details are not shown, on a frame or platform bracketed from the wall or suspended from the ceiling. Carry supports to either the ceiling or the floor, or both as required, at locations where, because wall thickness is inadequate, it is not permitted to use such brackets.
- .15 Electrical panels, switches or other electrical equipment shall be complete with suitable bases or mounting brackets. Install angle or channel iron supports to bear the equipment where it is shown in or on structural tile walls, or walls that are inadequate to bear the equipment.
- .16 Provide channel iron or other metal supports where necessary to adequately support lighting fixtures. Do not use wood. Lighting fixtures shall be supported totally independent of ceiling and supported from structure above.
- .17 Support hangers, in general, from inserts in concrete construction or from building structural steel beams, using beam clamps. Provide additional angle or channel steel members required between beams for supporting conduits.
- .18 Do not use explosive drive pins in any section of work without obtaining prior written approval.
- .19 Provide re-enforced concrete pads under switchboards, generators, and all other floor mounted electrical equipment. Pads are to be formed with chamfered edges to prevent chipping. Pads are to be sealed and painted to prevent dust from entering and interfering with electrical equipment.

3.2 Housekeeping Pads

- .1 Conform to Specification section 26 05 01.

END OF SECTION

SPLITTERS, JUNCTION AND PULL BOXES, CABINETS

26 05 32

1 GENERAL

1.1 Scope

- .1 Provide splitters, junction boxes, pull boxes and cabinets.

1.2 Related Sections

- .1 Without limiting the scope of work or applicability of other specification sections, the work under this section directly integrates with or refers to the following specification sections:
 - .1 26 24 16.14 Panel Trim

1.3 Applicable Codes and Standards

- .1 Product standards:
 - .1 CSA C22.2 No. 76 Splitters.
 - .2 CSA C22.2 No. 40 Junction and Pull Boxes.

1.4 Submittals

- .1 Submit shop drawings and product data for cabinets in accordance with Section 26 05 01 Electrical General Requirements.

2 PRODUCTS

2.1 Splitters

- .1 Sheet metal enclosure, welded corners and formed hinged cover suitable for locking in closed position.
- .2 Main and branch lugs and connection bars to match required size and number of incoming and outgoing conductors as indicated.
- .3 At least three spare terminals on each set of lugs in splitters.
- .4 Distribution riser splitters shall be of special construction with hinged access door, copper bus bars predrilled to accept two hole compression connectors for all incoming and outgoing cables.

2.2 Junction and Pull Boxes

- .1 Welded steel hot dipped galvanized construction with screw-on flat covers for surface mounting.
- .2 Covers with 25 mm (1") minimum extension all around, for flush-mounted pull and junction boxes.

2.3 Cabinets

- .1 Type E: sheet steel, hinged door and return flange overlapping sides, handle, lock and catch, for surface mounting.
- .2 Type T: sheet steel cabinet, with hinged door, latch, lock, 2 keys, containing sheet steel backboard for surface or flush mounting as indicated.
- .3 Cabinet trim to conform to Specification section 26 24 16.14.
- .4 Surface mounted cabinet finish colour: ASA 61 grey.

2.4 Instrumentation and Control Terminal Cabinets

- .1 Surface mounted, gasketed, drip proof and dust tight, JIC enclosure, CEMA type 12 With hinged door, lock, 2 keys, white raised and removable internal mounting panel, diagram pocket, finished with ASA 61 grey.

Standard of Acceptance

- Hammond
- .2 Panel wiring to be contained in PVC wiring ducts complete with cover strips, minimum 50 mm x 50 mm (2" x 2"). Wireway fill to be limited to 60%. Where there are a large number of door mounted devices, door wiring harnesses shall also be contained in wiring ducts at rear door. All door wiring devices to emanate from the control panel terminal strips. Wiring to panel face mounted devices to be bundled neatly on hinge side of panel, enclosed in flexible spiral wrap, and installed such that wiring will not be damaged when opening and closing door. Ground panel door to panel with a flexible copper bonding strap. Label all wiring with permanent PVC sleeve type markers.
 - .3 Phoenix contact terminal blocks with mounting rails, end covers, terminal markers, partition plates and accessories: UK 2.5 termination of wiring 22 to 12 AWG; UK 5 and UK 10 series for current transformers and other leads #10 AWG and #8 AWG; UDK or UK 5 twin for connecting two or more conductors to one terminal block; DIK 1.5 for three wire sensor device wiring; MTKD for thermocouple leads.
 - .4 Provide lamacoid nameplates for all panel mounted control and indicating devices, and all internal components such as terminal strips, control transformers, control devices, relays, etc. as per 26 05 01.

3 EXECUTION**3.1 Splitter Installation**

- .1 Install splitters and mount plumb, true and square to the building lines.
- .2 Extend splitters full length of equipment arrangement except where indicated otherwise.

3.2 Junction, Pull Boxes and Cabinets Installation

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

3.3 Identification

- .1 Provide equipment identification in accordance with Section 26 05 01 - Electrical - General Requirements.
- .2 Install size 2 identification labels indicating system name, voltage, phase and source of power.
- .3 Provide a typed directory in cabinets showing following information: Nature, actual quantities and room number of device or devices connected to each terminal, as well as signal circuit number where applicable.

END OF SECTION

CONDUITS, FASTENINGS AND FITTINGS

26 05 33

1 GENERAL

1.1 Scope

- .1 Provide conduits, fastenings and fittings for electrical conductors.

1.2 Submittals

- .1 Submit shop drawings and product data for products specified herein.

1.3 Applicable Codes and Standards

- .1 Product standards:
 - .1 CSA C22.2 No. 18.1 Metallic Outlet Boxes
 - .2 CSA C22.2 No. 45.1 Electrical Rigid Metal Conduit - Steel
 - .3 CSA C22.2 No. 83 Electrical Metallic Tubing
 - .4 CSA C22.2 No. 56 Flexible Metal Conduit and Liquid-Tight Flexible Metal Conduit
 - .5 CSA C22.2 No 211.2 Rigid PVC (unplasticized) Conduit

2 PRODUCTS

2.1 Conduits

- .1 Rigid hot dipped galvanized steel threaded conduit to CSA C22.2 No. 45.1.
 - .1 epoxy coated rigid galvanized steel conduit: with zinc coating and corrosion resistant epoxy finish inside and outside equal to Columbex Green Guard II
 - .2 PVC coated hot dipped galvanized rigid steel conduit: with 40 mil PVC exterior coating, 2 mil urethane interior and thread coating equal to Rob Roy Plastibond RedHot
- .2 Electrical metallic tubing (EMT), hot dipped galvanized: with couplings to CSA C22.2 No. 83
- .3 Rigid PVC conduit to CSA C22.2 No 211.2.
- .4 Flexible metal conduit and liquid-tight flexible metal conduit to CSA C22.2 No. 56.
- .5 Size conduits sufficiently to allow easy removal of conductors at any time. Conduit sizes, where shown, are minimum and shall not be reduced.

2.2 Conduit Fastenings

- .1 One hole steel straps to secure surface conduits 50 mm (2 in.) and smaller. Two hole steel straps for conduits larger than 50 mm (2 in.).
- .2 Beam clamps to secure conduits to exposed steel work.
- .3 Channel type supports for two or more conduits.
- .4 Six mm dia threaded rods to support suspended channels.

2.3 Conduit Fittings

- .1 Fittings: manufactured for use with conduit specified. Coating: same as conduit.
- .2 Factory "ells" where 90 degree bends are required for 25 mm (1 in.) and larger conduits

- .3 Insulated throat steel set screw or raintight insulated throat steel compression connectors and couplings for EMT.
- .4 Threaded or compression type raintight/concrete tight insulated throat zinc plated steel connectors and couplings for rigid steel conduit.
- .5 Raintight insulated throat steel connectors at all surface panelboards, switchboards and other electrical equipment in sprinklered areas for all conduit terminations.

2.4 Expansion Fittings

- .1 Electrogalvanized steel with internal grounding for EMT suitable for 100mm (4 in.) linear conduit movement.

Standard of Acceptance

- Cooper Crouse Hinds XJG-EMT
- .2 Weatherproof expansion fittings with internal bonding assembly suitable for 100mm (4 in.) linear expansion.
- .3 Watertight expansion fittings with integral bonding jumper suitable for linear expansion and 19 mm (3/4 in.) deflection in all directions.
- .4 Concrete type, water tight, corrosion resistant for conduit installations embedded in concrete
- .5 Weatherproof expansion fittings for linear expansion at entry to panel.

2.5 Fish Cord

- .1 Polypropylene.

3 EXECUTION

3.1 Location of Conduit

- .1 Drawings do not indicate all conduit runs. Those indicated are in diagrammatic form only.

3.2 Installation

- .1 Install conduits to conserve headroom in exposed locations and cause minimum interference in spaces through which they pass.
- .2 Conceal conduits except in mechanical and electrical service rooms and in unfinished areas.
- .3 Use electrical metallic tubing (EMT) except: in cast concrete, underground or where installed exposed within 2.0m (6'-6") of floor.
- .4 Use rigid galvanized steel conduit where installed surface mounted within 2.0m (6'-6") of floor.
- .5 Use rigid PVC conduit in slab on grade cast concrete and underground. Do not use PVC conduits in slabs above grade. All conduits shall be surface mounted to minimize risks of future damage when core drilling during future renovations. Where localized congestion or circumstances forces the use of conduits in the floor slabs, they shall be epoxy coated rigid galvanized steel.
- .6 Provide PVC conduit with bonding conductor as per Table 16A of Ontario Electrical Safety Code.
- .7 Use liquid tight flexible metal conduit for connection to motors or vibrating equipment
- .8 Use explosion proof flexible connection for connection to explosion proof motors.
- .9 Install conduit sealing fittings in hazardous areas. Fill with compound.

- .10 Use raintight connectors or hubs for terminating conduits at all surface or floor mounted panelboards, switchboards, and other equipment located in sprinklered areas or where at risk of exposure to dripping liquids.
- .11 Install wiring in conduit unless otherwise specified.
- .12 Bend conduit cold. Replace conduit if kinked or flattened more than 1/10th of its original diameter.
- .13 Mechanically bend steel conduit over 19mm (3/4") dia.
- .14 Field threads on rigid conduit must be of sufficient length to draw conduits up tight.
- .15 Install fish cord in empty conduits.
- .16 Where conduits become blocked, remove and replace blocked section. Do not use liquids to clean out conduits.
- .17 Dry conduits out before installing wire.
- .18 Conduit manufacturer's touch up enamel shall be used to repair all scratches and gouges on epoxy-coated conduit.
- .19 Install junction boxes or cable anchor boxes wherever necessary for proper pulling or anchoring of cables. Install so as to be accessible after building is completed and set to come within finished lines of building.
- .20 Where EMT or rigid PVC is used, run green insulated bonding conductor in conduit, with minimum one bonding conductor per three ungrounded conductors.
- .21 Provide expansion couplings, with bonding jumper and ground clamps where raceways cross building control joints.
- .22 Where circuits are required in the vicinity of a steel roof deck:
 - .1 support the conduits, EMT or cables at least 38mm (1½") below the underside of the deck,
 - .2 do not run conduits, EMT or cables on the top side of the roof deck,
 - .3 do not cut openings in the roof deck unless specifically indicated,
 - .4 where circuits must be located within 38mm (1½") of the underside of a roof deck, use galvanized rigid steel conduit and cast fittings,
 - .5 where there is no option to running conduits on the top side of a roof deck, use epoxy or PVC coated galvanized rigid steel conduit with epoxy or PVC coated cast fittings.
- .23 Where conduits or cables are installed under raised floors and are required to be fastened in place, use two hole inverted "U" straps. No sharp edges or corners will be permitted which may damage PVC jackets or cables.
- .24 Runs of conduit and cables, where shown, are indicated only by general location and routing. Install conduits and cables so as to provide maximum head room and to interfere as little as possible with free use of spaces through which they pass. They shall be installed as close to building structure as possible such that, where concealed, necessary furring can be kept to a minimum. Arrange conduits, installed in suspended ceilings, to provide minimum interference with removal of tiles.

3.3 Wiring Methods

- .1 Install wiring in surface mounted EMT conduit unless otherwise specified. In finished areas, conceal conduit in walls and ceiling spaces.
- .2 In areas designated as Explosion Proof on Drawings, conduit and wiring shall be Class I, Group D, Division I.
- .3 Where shown on drawings, armoured cable shall be Teck 90 type. Jackets of cable shall have FT-4 rating identified. Connectors shall be equal to ABB Installation Products Ltd. (T & B) - Star Teck Type.

- .4 Rigid PVC conduit with ground wire as per Electrical Safety Code Table 16 shall be used throughout below grade areas and may be used in or under slab on grade areas. It shall not be used in above grade slabs.
- .5 Epoxy enamel or PVC coated rigid galvanized steel conduit shall be used throughout basement; in damp locations including but not limited to intake and exhaust shafts and air handling units; for rigid metallic conduit underground or in floor slabs; for wiring outdoors and in unheated buildings; and where noted on Drawings.
- .6 Runs of conduit and cables, where shown, are indicated only by general location and routing. Install conduits and cables so as to provide maximum head room and to interfere as little as possible with free use of spaces through which they pass.
- .7 Use EMT conduit for branch circuit and signal wiring in ceilings, furred spaces, and in hollow walls and partitions.
- .8 Use rigid galvanized steel conduit for wiring where conduits are exposed to possible mechanical damage.
- .9 Use epoxy coated rigid galvanized steel conduit for wiring in poured concrete.
- .10 Aluminum conduits shall not be used
- .11 Flexible conduit and armoured cable will be accepted in parts of existing building, where furred spaces above ceilings are too congested to permit conduit to be installed, but only with Consultant's written permission. Terminate armoured cable, where shown, in accordance with the manufacturer's recommendations.
- .12 Flexible steel conduit with integral insulated green ground wire is permitted for the final connection to luminaires mounted in suspended ceilings from the branch wiring junction box above, with flexible conduit length not to exceed 3 m (10'), and be neatly installed and attached to luminaire support chain
- .13 Flexible armoured conduit (or BX) with an integral insulated green ground wire may be used where concealed in walls for wiring to receptacles, and for the final connection to luminaires.
 - .1 The junction box interfacing the horizontal EMT conduit to the flexible conduit shall be located within 3 m (10') horizontally from the end device in open areas, and in enclosed rooms, located in the same room as the devices being served, in reasonable proximity to the walls, in order to keep the horizontal portion of the run of flexible conduit to less than 3 m (10').
 - .2 The flexible conduit shall be neatly installed parallel or perpendicular to building lines, and independently supported from the slab structure above.
- .14 Conduit shall be of sufficient size to permit easy removal of conductors at any time. Conduit sizes, where shown, are minimum and shall not be reduced.
- .15 Arrange conduits, installed in suspended ceilings, to provide minimum interference with removal of tiles.
- .16 Where existing locations of flush mounted electrical devices (switches, receptacles, etc.) correspond to new devices shown, the existing dropdown conduit and outlet box may be re-used. Provide new devices, new coverplates, new home-run conduit and complete new wire.
- .17 Vertical raceways to be provided with insulated cable support bushings or other approved method of supporting the weight of the cable, where vertical runs exceed those of Table 21 of the Electrical Code.

3.4 Surface Conduits

- .1 Run parallel or perpendicular to building lines.
- .2 Locate conduits behind infrared or gas fired heaters with 1.5m (5') clearance.
- .3 Run conduits in flanged portion of structural steel.
- .4 Group conduits wherever possible on suspended or surface channels.

- .5 Do not pass conduits through structural members except as indicated.
- .6 Do not locate conduits less than 75 mm (3") parallel to steam or hot water lines with minimum of 25 mm (1") at crossovers.

3.5 Concealed Conduit

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

3.6 Conduits in Cast-in-place Concrete

- .1 Locate to suit reinforcing steel. Install in centre one third of slab.
- .2 Protect conduits from damage where they stub out of concrete.
- .3 Install sleeves where conduits pass through slab or wall.
- .4 Where conduits pass through waterproof membrane provide oversized sleeve before membrane is installed. Use cold mastic between sleeve and conduit.
- .5 Do not place conduits in slabs in which slab thickness is less than 4 times conduit diameter.
- .6 Encase conduits completely in concrete with minimum 25 mm (1") concrete cover.
- .7 Organize conduits in slab to minimize cross-overs.

3.7 Conduits in Cast-in-place Slabs on Grade

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

3.8 Conduits Underground

- .1 Slope conduits to provide drainage.

END OF SECTION

OUTLET BOXES, CONDUIT BOXES AND FITTINGS

26 05 35

1 GENERAL

1.1 Scope

- .1 Provide outlet boxes, conduit boxes and fittings for electrical services.

1.2 Related Sections

- .1 Without limiting the scope of work or applicability of other specification sections, the work under this section directly integrates with or refers to the following specification sections:
 - .1 26 27 28 Wire and Box Connectors 0-1000V

1.3 Applicable Codes and Standards

- .1 Product standards:
 - .1 CSA C22.2 No. 18. Outlet Boxes, Conduit Boxes, and Fittings

2 PRODUCTS

2.1 General

- .1 Outlet boxes, conduit boxes, and fittings listed to CSA C22.2 No. 18.

2.2 Outlet and Conduit Boxes - General

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

2.3 Sheet Steel Outlet Boxes

- .1 Hot dipped galvanized steel single and multi gang flush device boxes for flush installation, minimum size 76 mm x 50 mm x 38 mm (3" x 2" x 1½") or as indicated. 102 mm (4") square outlet boxes when more than one conduit enters one side with extension 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.

2.4 Masonry Boxes

- .1 Hot dipped galvanized steel masonry single and multi-gang boxes for devices flush mounted in exposed block walls.

2.5 Concrete Boxes

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

2.6 Floor Boxes

- .1 Concrete tight hot dipped galvanized sheet steel floor boxes with adjustable finishing rings to suit floor finish with brass or brushed aluminum faceplate. Device mounting plate to accommodate short or long ear duplex single or receptacles. Minimum depth: 28 mm (1¼") for receptacles; 73 mm (3") for communication equipment.
- .2 Adjustable, watertight, concrete tight, cast floor boxes with openings drilled and tapped for 12 mm (½") and 19 mm (¾") conduit. Minimum size: 73 mm (3") deep.

2.7 Conduit Boxes

- .1 Cast FS boxes with factory-threaded hubs and mounting feet for surface wiring of switches and receptacle, outside building and where weatherproof boxes are required.
- .2 Explosion proof boxes in areas indicated on drawings.

2.8 Fittings - General

- .1 Bushing and connectors with nylon insulated throats.
- .2 Knock-out fillers to prevent entry of debris.
- .3 Conduit outlet bodies for conduit up to 32 mm (1½") and pull boxes for larger conduits.
- .4 Double locknuts and insulated bushings on sheet metal boxes.

2.9 Acoustical Putty Pads

- .1 Moldable putty sheets:
 - .1 3mm (1/8") thick,
 - .2 Sound Transmission Class (STC) rating of not less than 23 for one layer,
 - .3 self adhesive,
 - .4 non-combustible,
 - .5 non-hardening,
 - .6 non-shrinking,
 - .7 non-corrosive to:
 - (a) boxes,
 - (b) EMT,
 - (c) conduit,
 - (d) PVC,
 - .8 asbestos free.

Standard of Acceptance

- 3M - Fire Stop Moldable Putty Pads
- Hilti – Firestop Putty Pads
- Kinetics - IsoBacker

3 EXECUTION**3.1 Installation**

- .1 Support boxes independently of connecting conduits.

- .2 Fill boxes with paper, sponges or foam or similar approved material to prevent entry of debris during construction. Remove upon completion of work.
- .3 For flush installations mount outlets flush with finished wall using plaster rings to permit wall finish to come within 6 mm (¼") of opening.
- .4 Provide correct size of openings in boxes for conduit, mineral insulated and armoured cable connections. Reducing washers are not allowed.
- .5 Provide a suitable outlet box for each light, switch, receptacle or other outlet, approved for the particular area in which it is to be installed.
- .6 Locate outlet boxes, mounted in hung ceiling space, so they do not obstruct or interfere with the removal of lay-in ceiling tiles.
- .7 Offset outlet boxes, shown back to back in partitions, horizontally to minimize noise transmission between adjacent rooms.
- .8 Box connectors to conform to Specification section 26 27 28.
- .9 For outlet boxes installed in walls with a Sound Transmission Class (STC) rating:
 - .1 apply acoustical putty pads to the outlet box,
 - .2 cover all openings and EMT, conduit and cable entrances/exits,
 - .3 install putty pads on the outside of boxes,
 - .4 provide additional layers and/or provide other sound control measures, as necessary to maintain the STC rating of the wall assembly,
 - .5 install pads and other sound control measures, if applicable, in accordance with the manufacturers recommendations.
- .10 Use gang boxes at locations where more than one device is to be mounted. Use combination boxes with suitable barriers where outlets for more than one system are shown.
- .11 Where 100 mm (4") square boxes are installed in exposed concrete or cinder block in finished areas, blocks will be cut under masonry division as instructed under this section. Openings shall be cut to provide a close fit to boxes and covers so that edges of openings are not visible after installation of plates. Mortar shall not be used to patch up openings that are cut too large or to patch ragged edges.
- .12 Where boxes are required for wiring and equipment on the underside of a steel roof deck:
 - .1 support the boxes at least 38mm (1½") below the underside of the deck,
 - .2 do not cut openings in the roof deck unless specifically indicated,
 - .3 where boxes must be located within 38mm (1½") of the underside of a roof deck, use cast conduit boxes.

END OF SECTION

Cable Tray for Electrical Systems 26 05 36

1 GENERAL

1.1 Scope

- .1 Provide cable tray, associated support hangers and accessories as shown.

1.2 Applicable Codes and Standards

- .1 Product standards:
 - .1 CSA C22.2 No.126.1 Metal Cable Tray Systems.

1.3 Submittals

- .1 Submit shop drawings and product data for each type and size of tray.
- .2 Identify cable tray types with terminology used in Part 2.
- .3 Show actual cable tray installation details and support systems.

2 PRODUCTS

2.1 Ladder Type Cable Tray

- .1 Size as shown and as required.
- .2 Rung spacing: 300mm (12").
- .3 Load rating: Class C.
- .4 Material: aluminum.
- .5 Accessories and fittings as shown and as required for a complete system.
- .6 Accessories and fittings of same manufacture and material as the tray, including:
 - .1 horizontal elbows,
 - .2 end plates,
 - .3 box connectors,
 - .4 drop outs,
 - .5 vertical risers,
 - .6 drops,
 - .7 tees,
 - .8 wyes,
 - .9 expansion joints,
 - .10 reducers,
 - .11 barriers,
 - .12 covers (vented, solid),
 - .13 peaked covers (vented, solid),
 - .14 bonding jumpers (copper).
- .7 Inside radius of bends, not less than: 600mm (24.
- .8 Hardware: stainless steel.

Standard of Acceptance

- Canadian Electrical Raceways
- Commercial Roll Formed Products - Comtray
- Cooper B-Line – Cable Tray
- Cope Ladder
- Legrand
- MP Husky
- ABB Installation Products Ltd. (T & B)

2.2 Supports

- .1 Hanger rods: stainless steel .
- .2 Refer to Structural drawings and Specifications.

3 EXECUTION**3.1 Installation - General**

- .1 Install in accordance with the manufacturer's recommendations.
- .2 Use tools as recommended by the manufacturer, in particular use offset blade cutters to cut wire mesh tray.
- .3 Do not install tray, fasteners or supports that have a zinc plated finish, in the following areas:
 - .1 computer rooms,
 - .2 telecommunications rooms,
 - .3 under raised floors.
- .4 Where the tray supports fire rated mineral insulated cables, use stainless steel tray.
- .5 Install parallel or perpendicular to building lines. Where not possible, obtain instructions from the Consultant.
- .5 Support on 2000mm (6.5') centers, except where indicated otherwise.
- .6 Confirm with the Consultant, the ultimate cable loading for each run.
- .7 Provide additional supports as required to suit the ultimate loading.
- .8 Support both sides of tray using trapeze hangers, except where shown otherwise.
- .9 Provide supports on each side of an expansion fitting or gap.
- .10 Attach supports directly to the building structure.
- .11 To permit installation of rollers and cables, maintain a clear space above the tray of at least:
 - .1 150mm (6") for trays supporting cables up to 25mm outside diameter,
 - .2 225mm (9") for trays supporting cables larger than 25mm and up to but not including 50mm outside diameter,
 - .3 300mm (12") for trays supporting cables of 50mm or larger outside diameter,
 - .4 300mm (12") to ceilings, heating ducts and heating equipment.
- .12 Install tray with side clearances of not less than:
 - .1 600mm (24") on one side, for tray up to 1000mm wide, mounted on wall brackets or trapeze hangers,

- .2 600mm (24") on both sides, for tray wider than 1000mm, mounted on wall brackets or trapeze hangers,
- .3 600mm (24") on one side and 150mm (6") on the other side, for center hung tray up to 1000mm wide.
- .13 Ensure that no other services or hangers are installed through the web space of the tray.
- .14 Brace to withstand loads due to pulling in of cables.
- .15 Brace to withstand seismic loads.
- .16 Provide covers where indicated:
 - .1 secure with clips supplied by the tray manufacturer,
 - .2 for outdoor installations bolt covers to the tray using stainless steel hardware, provide sufficient attachment in accordance with the manufacturer's recommendations to ensure that covers will remain in place when exposed to wind speeds of 160 km/hr. (100mph).
- .17 Remove sharp burrs or projections to prevent damage to cables or injury to personnel.
- .18 File cuts smooth.
- .19 For galvanized trays, coat cut edges with a galvanizing compound.
- .20 Where other wiring methods are connected to cable tray:
 - .1 provide a mechanical attachment using tray manufacturer's fittings,
 - .2 arrange the connection to prevent damage to conductors,
 - .3 provide effective bonding.
- .21 Provide expansion fittings where tray:
 - .1 crosses a building expansion joint,
 - .2 where required to accommodate thermal expansion.
- .22 For ladder and center spine type trays, a gap, bridged with a flexible bonding jumper, is acceptable as an expansion fitting.
- .23 For center spine and wire mesh trays, provide cable bending radius protectors at bends, tees, wyes, crosses and dropouts.
- .24 Use hardware of the same material as the tray. Where hardware must be of a different material, the material to have equivalent corrosion resistance as the tray. Obtain Consultant's acceptance of hardware manufactured from materials different from the tray.
- .25 Install tray as a bonding conductor with bonding continuity from end to end and with associated electrical equipment.
- .26 Provide bonding jumpers at each joint in the tray and between tray and associated electrical equipment. Splice plates, fittings, clamps are acceptable as bonding jumpers if they are CSA listed for the purpose.
- .27 Provide #1/0 green bonding conductor in each run of cable tray used for power cables rated 120 volts to 600 volts, and #4/0 for each run used for power cables rated over 600 volts. Bond bonding conductor to each section of tray at 6m (20') intervals using an approved ground clamp, such as Burndy GC. Connect bonding conductor to ground bus at each end of run with a compression connector.
- .28 For trays used for communications cabling, provide:
 - .1 a copper insulated green bonding conductor, not less than #6, from the tray to the ground bus in each equipment room served by the tray,
 - .2 a copper insulated green bonding conductor, not less than #6, across each joint in the tray,
 - .3 connect the bonding conductor to the tray using a suitable copper split bolt or using bonding hardware supplied by the tray manufacturer.

3.2 Installation of Cables in Tray

- .1 Install cables individually.
- .2 Lay cables into tray wherever possible.
- .3 Use rollers when necessary to pull cables.
- .4 Secure cables in tray at 1200mm (4') centers, with factory made non ferrous cable clamps.
- .5 Use aluminum clamps to secure single conductor cables, do not use nylon ties.
- .6 Nylon ties may be used for multiconductor cables where acceptable to the Consultant.
- .7 Identify cables every 30m (100') and at each end of the run with size 2 nameplates.
- .8 Do not exceed 80% of the load rating of the tray or the support system.
- .9 Additional Requirements for Installation of Cable Tray for Communications Wiring
 - .1 Maintain separation of cable tray from sources of electromagnetic interference as follows:

Item	Minimum Clearance
Fluorescent ballasts	150mm (6")
Conduit and cables used for electrical distribution less than 1kV	300mm (12")
Conduit and cables used for electrical distribution greater than 1kV	1000mm (36")
Motor	1200mm (48")
Transformer	1200mm (48")

- .10 The above table provides a guideline. Where equipment produces particularly high levels of electric or magnetic fields, provide greater clearances acceptable to the Consultant.
- .11 Wherever possible, install, tray so that communications conductors cross sources of interference at right angles. Where not possible obtain instructions from the Consultant.

END OF SECTION

VIBRATION ISOLATION

26 05 48

1 GENERAL

1.1 General Requirements

- .1 Conform to Section 26 01 01, Electrical General Requirements.
- .2 Conform to Section 26 05 01, Electrical Basic Materials and Methods.

1.2 Scope

- .1 It is the intent of this specification that vibration and noise from electrical building system components are attenuated to acceptable levels.
- .2 Provide design, selection and provision of materials, installation instructions, installation and inspection of vibration isolation equipment and systems.
- .3 Isolate equipment that produces vibrations, including:
 - .1 engine driven equipment,
 - .2 motor driven equipment,
 - .3 transformers,
 - .4 UPS equipment.
- .4 Install vibration isolation equipment and systems in accordance with the component manufacturer's recommendations. Where a conflict occurs between the requirements of this Section and the manufacturer's recommendations, apply the most stringent requirements.
- .5 Select vibration isolation equipment to maintain noise levels below the NC levels in the following schedule.

AREA	NOISE CRITERIA (NC level)
Offices - private	32 to 34
-open plan	36 to 38
Private Bedrooms	26 to 28
Hospital Wards	30 to 32
Public Areas	38 to 40

- .6 Coordinate the design and installation of vibration isolation with seismic restraint systems.
- .7 The requirements under this Section are in addition to the requirements for supports and vibration isolation specified in other Sections.

1.3 Related Section

- .1 Section 26 05 49 Seismic Restraint.

1.4 Manufacturer's Responsibility:

- .1 Manufacturer of vibration isolation components to:
 - .1 determine vibration isolation sizes and locations,
 - .2 supply suitable vibration isolation as required,
 - .3 supply installation instructions and drawings,
 - .4 provide trained field supervision personnel on site to insure proper installation,
 - .5 conduct site inspections of the Work in progress,
 - .6 conduct a final inspection of the Work,
 - .7 prepare a final inspection report of the installation.

1.5 Submittals

- .1 Submit shop drawings in accordance with Division 1 and as follows:
 - .1 details of suspension and support for ceiling and wall hung equipment,
 - .2 details of vibration isolation for each piece of equipment hung from the structure or supported from the floor,
 - .3 product data sheets for isolation components,
 - .4 load deflection curves,
 - .5 calculations of the expected deflection and the natural frequency.

2 PRODUCTS

2.1 Resilient Isolator Type 1 (R1)

- .1 Rubber waffle or ribbed pads:
 - .1 of 30 durometer natural rubber, not less than 13 mm ($\frac{1}{2}$ ") thick,
 - .2 suitable for loading up to 350 kPa. (50 psi).
- .2 Rubber-steel-rubber pads:
 - .1 two layers of rubber waffle or ribbed pad, 13 mm ($\frac{1}{2}$ ") thick, as specified above,
 - .2 bonded to 6 mm ($\frac{1}{4}$ ") steel plate with holes sleeved and fitted with isolation washers.
- .3 Neoprene jacketed precompressed moulded fibreglass.

2.2 Resilient Isolator Type 2 (R2)

- .1 Elastomer rubber with:
 - .1 threaded insert,
 - .2 hold down bolts.
- .2 Neoprene, 50 mm (2") free height:
 - .1 natural frequency not to exceed 15 Hz at full load,
 - .2 capable of sustaining a load of 110 kg (250 lb),
 - .3 with deflection not exceeding 5 mm (0.19").

2.3 Elastomeric Mounts

- .1 Neoprene in shear:
 - .1 colour coded,
 - .2 durometer not greater than 60,
 - .3 threaded insert,
 - .4 two bolt down holes,
 - .5 ribbed top and bottom surfaces.

2.4 Spring Mounts – General Requirements

- .1 Isolator springs:
 - .1 designed so that ratio of lateral to axial stiffness is equal to or greater than 1.2 times ratio of static deflection to working height,
 - .2 selected for 50% travel beyond rated load,
 - .3 cadmium plated,
 - .4 colour coded.
- .2 Mounts:
 - .1 zinc or cadmium plated hardware,
 - .2 rubber isolation washers,
 - .3 housings coated with rust resistant paint,
 - .4 levelling devices,
 - .5 6 mm (1/4") thick ribbed rubber sound pad bonded to load plate.
- .3 Clearance between metal parts to be not less than 6 mm (1/4").

2.5 Spring Isolator Type 1 (S1)

- .1 Open spring isolators:
 - .1 extra stiff springs with ratio of lateral to axial stiffness of 1.0.

2.6 Spring Isolator Type 2 (S2)

- .1 Controlled spring isolators:
 - .1 heavy rigid steel base frames,
 - .2 built-in vertical limit stops,
 - .3 removable spacers,
 - .4 extra stiff springs with ratio of lateral to axial stiffness of 1.0.

2.7 Isolation Hangers – General Requirements

- .1 Isolation hangers to have swivel arrangement to permit hanger box or rod to move through 20° arc without metal to metal contact.

2.8 Hanger Type 1 (H1)

- .1 Spring hanger:
 - .1 welded steel housing with one coat anti-rust paint,
 - .2 colour coded spring,
 - .3 retaining cups,
 - .4 elastomeric washers.

2.9 Hanger Type 2 (H2)

- .1 Rubber hanger:
 - .1 welded steel housing with one coat anti-rust paint,
 - .2 25 mm (1") colour coded neoprene in shear with durometer of not more than 60,
 - .3 threaded insert.

2.10 Hanger Type 3 (H3)

- .1 Horizontal thrust restraint:
 - .1 spring and elastomeric element,
 - .2 housed in box frame with rods and angle brackets to connect unit between isolated equipment and fixed object,
 - .3 fitted with means to adjust start-stop movement to not more than 9 mm (3/8").

2.11 Acoustic Barriers for Anchors and Guides

- .1 Manufactured from 25 mm (1") thick neoprene isolation with duck reinforcing material.

Standard of Acceptance

- Vibron / Kinetics
- BVA
- VMC / Korfund
- Mason
- Tecoustics

3 EXECUTION

3.1 General

- .1 Provide vibration isolation as required.
- .2 Install vibration isolation equipment in accordance with manufacturer's instructions.
- .3 Locate isolation for equipment to provide stable support under saddles, frames and projections of equipment.

3.2 Application

- .1 Provide additional steel in bases and rails to obtain rigidity and uniform load distribution.

- .2 Make flexible connections to isolated equipment so as to maintain isolation system flexibility and to allow full range of movement of the isolated equipment.

3.3 Start-up and Set-up

- .1 After installation of connections to resiliently mounted equipment:
 - .1 remove shims and blocking and adjust mountings to level equipment,
 - .2 adjust connections, hangers, snubbers and restraints,
 - .3 ensure that physical contact between isolated equipment and building structure cannot occur at limits of movement.
- .2 On completion of installation and start-up of equipment:
 - .1 manufacturer/supplier of Vibration Isolation equipment to visit site, check performance of systems, inspect installation and submit written recommendations,
 - .2 make corrections to installation in accordance with manufacturer/suppliers recommendations,
 - .3 provide notice 24 hours in advance of this site visit.
- .3 Provide a final inspection report signed by the manufacturer/supplier's representative, certifying that the vibration isolation equipment is suitable for the application and has been installed in accordance with the manufacturer's recommendations.

3.4 Testing

- .1 Engage and pay for an experienced sound and vibration professional to take measurements of sound and vibration generated by electrical systems.
- .2 Co-operate with manufacturer/supplier of Sound Attenuation equipment in this measurement and testing.
- .3 Sound measurements to extend over full audio frequency range and to be taken in areas adjacent to:
 - .1 main electrical rooms,
 - .2 electrical rooms containing one or more dry type transformers,
 - .3 engine generator (EG: diesel generator) rooms,
 - .4 UPS equipment rooms.
- .4 Submit outline of tests to be performed, details of instrumentation to be used and floor plans showing test locations prior to commencing work.
- .5 Provide notice one week in advance of commencement of tests.
- .6 Submit complete report of tests addressing noise and vibration levels measured in occupied areas and adequacy of Sound Attenuation and Vibration Isolation equipment.

END OF SECTION

SEISMIC RESTRAINT FOR ELECTRICAL SERVICES 26 05 49

1 GENERAL

1.1 Scope

- .1 Provide seismic restraint devices to limit movement of electrical equipment, conduit, bus duct, busway, cable, cable tray and wireway under seismic force and movement conditions.
- .2 Provide engineering services for the design, selection of materials, installation instructions, and inspection of seismic restraint devices.
- .3 The requirements under this Section are in addition to the requirements for support of electrical equipment, conduit, bus duct, busway, cable, cable tray and wireway, and vibration isolation specified in other Sections.
- .4 Where specifications of materials of this Section differ from those in other Sections of Division 26, this Section governs.

1.2 Definitions

- .1 The following definitions apply for the purpose of this section.

Conduit – an electrical raceway that includes rigid galvanized steel conduit, electro-metallic tubing (EMT), PVC conduit, aluminium conduit.

Transverse restraint - restraint(s) applied to limit motion perpendicular to the centerline of the conduit, bus duct, busway, cable, cable tray or wireway.

Longitudinal restraint - restraint(s) applied to limit motion parallel to the centerline of the conduit, bus duct, busway, cable, cable tray or wireway.

Restraint: a device which limits movement of object due to imposed seismic forces acting on the object.

Brace: a restraint directly connected to an object that reacts against both tension and compression seismic loads.

Cable restraint: a restraint consisting of cables that reacts against only tension seismic forces, and that may have a small amount of slack to prevent vibration isolation short-circuiting during normal operation.

Snubber (restraint): a restraint that does not come into contact with the object under normal operating conditions.

- .2 The following abbreviations apply to this section:

"C_p" the horizontal seismic force coefficient as defined in NFPA 13.

"K_s" horizontal seismic force coefficient (equal to $0.3 F_a S_a(0.2) I_E S_p$, as defined in the National Building Code of Canada.

"K

"v" vertical seismic force coefficient.

"W_p" the weight of the component subject to a seismic force.

- .3 Interpretation:

- .1 In this specification, the parameter “S_s” (spectral response acceleration at 5 Hz) in NFPA 13, ASHRAE, SMACNA and MSS SP-127 used for estimating the horizontal seismic force, has the same meaning as the parameter “S_a(0.2)” for the spectral response acceleration value at 0.2 seconds as defined in the National Building Code of Canada.

1.3 Applicable Codes and Standards

- .1 Installation standards and codes:
 - .1 ASHRAE D-90316 Practical Guide to Seismic Restraint
 - .2 ANSI/SMACNA Seismic Restraint Manual Guidelines for Mechanical Systems, 3rd edition.
- .2 Product standards:
 - .1 ACI 355.2 Qualification of Post-Installed Mechanical Anchors in Concrete
 - .2 ASTM A492 Standard Specification for Stainless Steel Rope Wire
 - .3 ASTM A1023 Standard Specification for Stranded Carbon Steel Wire Ropes for General Purpose
 - .4 ICC-ES AC01 Expansion Anchors in Masonry Elements
 - .5 ICC-ES AC106 Predrilled Fasteners (Screws) in Masonry
 - .6 ICC-ES AC156 Acceptance Criteria for Seismic Certification by Shake-Table Testing of Non-structural Components
 - .7 ICC-ES AC193 Mechanical Anchors in Concrete Elements
 - .8 ICC-ES AC308 Post-Installed Adhesive Anchors in Concrete Elements
- .3 Other documents:
 - .1 ASCE 7 American Society of Civil Engineers, Minimum Design Loads and Associated Criteria for Buildings and Other Structures

1.4 Seismic Analysis, Design and Inspection Services

- .1 Provide the services of a professional engineer, licensed in the province or territory of the Work and who specializes in seismic restraint of building services and equipment (the “Seismic Engineer”), for the design of seismic restraints and to provide inspection services of the completed installation.
- .2 Seismic Engineer design services;
 - .1 Provide the design of seismic restraint systems, including seismic restraint calculations for all connections of equipment to the structure.
 - .2 Provide design drawings showing locations of restraints and details of construction and attachment of restrains. Mark-ups of Consultant drawing or Contractor installation drawings may be used for this purpose.
 - .3 Analysis dead loads, static seismic loads and capacity of materials utilized for connections to equipment and structure. Analysis to detail anchoring methods, bolt diameter, embedment and/or welded length. All seismic restraint devices shall be designed to accept, without failure, the seismic forces acting on the equipment or components and their support and restraint attachments to the building structure.
- .3 Seismic Engineer inspection services;
 - .1 At periods during installation and at completion of the installation of the seismic restraint devices, the Seismic Engineer shall inspect the installation, identify and report deficiencies (if any) which are observed, and re-inspect the installation after deficiencies have been corrected.

- .2 Seismic Engineer to submit periodic inspection reports and a final inspection report after all work is completed and deficiencies have been corrected, confirming the installation conforms to the seismic design requirements. Prepare and submit any required declarations or similar document to this effect where required by local legislation.
- .4 Shop drawings of custom restraints, required calculations, and reports shall be sealed by the specialist seismic professional engineer.
- .5 Prepare and submit reports of inspections of the installation and a final general review report of the completed seismic installation.

1.5 Manufacturer's Services – Seismic Restraints

- .1 Manufacturer of seismic control equipment are responsible for:
 - .1 determining seismic restraint sizes and locations,
 - .2 provide calculations and supply materials for restraint of vibration isolated and non-isolated equipment,
 - .3 provide installation instructions, drawings and trained field supervision to ensure proper installation and performance including welding details,
 - .4 field inspection of manufactured support systems including roof curbs and other rooftop equipment supports at time of installation.
- .2 Seismic restraint products shall either be:
 - .1 approved by a government agency and indicate maximum restraint ratings, or
 - .2 provided with test results verified by an independent testing laboratory which state the maximum restrain ratings.

1.6 Design Criteria

- .1 Design seismic restraint systems to conform to the provincial or territorial building code as applicable for the place of the Work. Seismic calculation and restraint methods as described in ASHRAE D-90316, and SMACNA seismic guideline are acceptable as the baseline requirement.
- .2 Design of seismic restraints to be based on actual equipment data (dimensions, weight, center of gravity, etc.,) obtained from submittals or the manufacturers of the equipment.
- .3 Testing and calculations of seismic restraints shall include both shear and tensile loads as well as one test or analysis at 45° to the weakest mode.
- .4 Site design parameters:

Item	Description	Abbrev.	Value
1	Soil Class	--	C
2	Building Category	---	Post-Disaster
3	Building Importance Factor	I _E	1.5
4	Spectral response acceleration factor	Sa(0.2)	0.144
5	Peak Ground Acceleration factor	PGA	0.088
6	Interstorey displacement factor	---	0.01

- .5 Building seismic force coefficient data;

- .1 seismic horizontal force coefficients " K_s " and seismic vertical uplift force coefficient " K_v " for building service are listed in Schedule A attached to the end of this Section. These coefficients are the maximum values independent of the type of equipment or service being restrained. It is permitted to calculate a lower K_s coefficient where the C_p , A_r and R_p values, as defined in the building code specific to the actual equipment or service being restrained, are used.
- .6 Seismic force;
- .1 the horizontal seismic force " V_p " applied to a component is:
- $$V_p = K_s \times W_p,$$
- .2 the vertical seismic force " V_{pv} " applied to a component is:
- $$V_{pv} = K_v \times W_p$$
- .7 For suspended equipment, the building elevation height is measured to the level of the floor above the suspended equipment.
- .8 For vibration isolated equipment, where the clearance distance (air gap) between the equipment support frame and the restraint (e.g. snubber or integral limit stop) exceeds 6 mm (1/4 in.), the seismic horizontal force V_p is to be increased by 100%.
- .9 Where adhesive anchors for concrete are used, the seismic force for the restrained equipment is to be increased by multiplying the horizontal seismic force coefficient specified in Schedule A of this Specification section by the " R_p " equipment category as defined in article 4.1.8.18 of the National Building Code of Canada specific to the equipment being restrained.

$$K_{s,adhesives} = K_s \times R_{p,applicable\ equipment}$$

- .10 Where concrete inserts are used, the seismic force for the restrained equipment is to be increased by multiplying the horizontal seismic force coefficient specified in Schedule A of this Specification section by the " R_p " equipment category as defined in article 4.1.8.18 of the National Building Code of Canada specific to the equipment being restrained and divided by the value of 1.5.

$$K_{s,inserts} = K_s \times \frac{R_{p,applicable\ equipment}}{1.5}$$

1.7 Seismic Qualification of Equipment

- .1 Applies where other specifications of Division 26 to 28 require equipment to be seismically qualified.
- .2 Design unitary or package equipment to withstand the seismic force criteria as specified herein.
- .3 Design the equipment base frame to allow anchoring of the packaged equipment to the supporting structure by use of through-bolt anchors.
- .4 Seismically qualify and certify complete unitary or packaged equipment by the shaker table method in accordance with ICC ES-AC156 and ASCE 7 for validating continued operation after the test seismic movement.
- .5 For clarity, calculation of seismic forces for use with ASCE 7 are subject to the following for installations in Canada:
- .1 calculate seismic forces in accordance with the building code at the place of the Work, or in its absence the National Building Code of Canada,
- .2 under ASCE 7, the " S_{DS} " parameter is equivalent to NBCC value equal to " $2/3 \cdot F_a(0.2) \cdot S_a(0.2)$ "
- .3 under ASCE 7, the Component importance factor is to be read as the Building Importance Factor in accordance with the National Building Code of Canada,
- .4 unless otherwise specified in the product technical Specification section, the building height factor under ASCE 7 of " z/h " is the same as NBCC " h_x/h_n " and is to have a value of 1.0.

- .5 other factors in conformance with this Specification section.

1.8 Submittals

- .1 Submit shop drawings in accordance with Division 1 and as follows.
- .2 Seismic restraints:
- .1 Provide test certificates for each seismic restraint device, identifying maximum tested load capacities.
 - .2 Provide calculations for each piece of restrained equipment, lengths of braced conduit bus duct, busway, cable, cable tray and wireway including seismic forces, restraint selection, and selection data.
 - .3 Provide a calculation analysis summary (spreadsheet is acceptable) for each piece of equipment, including the following information:
 - (a) Equipment ID,
 - (b) Floor level,
 - (c) Horizontal seismic force factor,
 - (d) Equipment weight,
 - (e) Horizontal seismic force,-
 - (f) Vertical uplift seismic force (where applicable),
 - (g) Design condition (worst case) overturning moment,
 - (h) Number of restraint fastenings,
 - (i) Pull-out tension for worst case restraint,
 - (j) Compression for worst case restraint (vibration isolated equipment),
 - (k) Horizontal shear per fastener,
 - (l) Worst case simultaneous tension and shear loads at each restraint and snubber,
 - (m) Pull-out tension load rating per fastener,
 - (n) Horizontal shear rating per fastener.
 - .4 Provide drawings for each type of restraint assembly, including details for connections to building structure, and associated bill of materials, and (where applicable) full welding details of field welds to structural elements.
 - .5 For building connections in concrete, provide concrete anchor sizes and nominal and effective embedment depth.
 - .6 Provide floorplan layout drawings indicating location of each restraint, identifying each restraint type in a manner to identify the restraint detail.
 - .7 Provide layout and construction details for reinforced housekeeping pads based on actual equipment to be restrained and selected concrete anchors. Shop drawings to include:
 - (a) minimum housekeeping pad plan dimensions and height, including reinforcement,
 - (b) details for securing the housekeeping pad to the structural floor slab,
 - (c) dimensioned position of restraint devices or combination isolator/restraint devices,
 - (d) minimum distance from concrete anchors to edge of housekeeping pad.
 - .8 Calculations and designs shall be sealed by a Professional Engineer licensed in the province or territory of the location of the project.
- .3 Electrical distribution riser support system:

- .1 Provide engineered layout drawings of electrical distribution riser supports including support/restraints, with supporting load calculation including dead loads and static seismic loads, and reaction loads at building connection.

1.9 Quality Assurance

- .1 Without limiting Contractors responsibility for quality assurance of the Work, the following minimum quality control processes are required.
- .2 Pre-Construction meeting;
 - .1 Request and arrange a meeting with the Seismic Engineer and Consultant to review seismic restraint approach, prior to any restraint installation. Obtain approval from the Consultant before commencing work.
- .3 Initial installation and review;
 - .1 Install the first three transverse and three longitudinal braces for each conduit type, bus duct, busway and cable tray system.
 - .2 Request and arrange for a review of the installation by the Seismic Engineer and Consultant. Obtain approval of the installation before commencing remainder of the work.
- .4 Provide services of the manufacturer's technical representative to conduct site inspections of the Work in progress, and to conduct a final inspection of the Work. Provide a copy of the final inspection report to the Consultant for review. For clarity, these inspections are separate from those performed by the Seismic Engineer.
- .5 Provide services by the Seismic Engineer to conduct periodic reviews of the work in progress, and final review of the completed seismic restraint installation, before any ceilings are installed or work is otherwise concealed.
- .6 All deficiencies identified by the Seismic Engineer, manufacturer, or Consultant are to be rectified before equipment or services are concealed.

2 PRODUCTS

2.1 General

- .1 Seismic restraint materials to be provided by manufacturers specializing in the field of seismic restraint.

Standard of Acceptance

- Vibro-Acoustics (Swegon North America)
 - Kinetics Noise Control Inc.
 - B.V.A. Systems
 - Korfund (VMC)
 - Tecoustics
 - Hilti
 - nVent
- .2 Manufactured seismic restraints, anchors and related materials to be tested in accordance with ICC ES AC156 for loads meeting or exceeding the applied seismic forces of the Work.
- .3 Seismic restraints for equipment supported by vibration isolators to be either:
 - .1 vibration isolators provided with separate seismic snubbers, or
 - .2 combination vibration isolators with integral seismic snubbers.

- .4 The following product articles describe the more common type of restraint devices. Other restraint devices are permissible provided they are qualified by 3rd party testing laboratories for seismic force restraint.

2.2 Seismic Snubbers

- .1 Type "SS1" – Single-Axis/Single Direction Snubbers:
 - .1 ASHRAE Type "I", designed to restrict movement in one axis,
 - .2 carbon steel construction with epoxy or electrostatic paint finish, attached to floor or housekeeping pad with minimum of two bolts, faced with minimum 6.4 mm (1/4 in.) thick neoprene pad of compounded to bridge bearing quality,
- .2 Type "SS2 / SS3" – Multi-Axis/Multi-Direction Snubber Assemblies:
 - .1 ASHRAE Type "G" and "F", designed to restrict movement in two (2) lateral ("SS2") or three (3) axis ("SS3"),
 - .2 interlocking steel construction, attached to equipment structure and equipment, maximum of 6 mm (1/4 in) seismic movement,
 - .3 minimum 6 mm (1/4 in) thick resilient neoprene pads compounded to bridge bearing specifications, to prevent metal-to-metal impact,
 - .4 minimum two bolt attachments to the floor,

2.3 Seismic Restraint Brackets

- .1 Type "SRB" – Rigid Equipment Restraint Brackets:
 - .1 suitable for connection to equipment bases and tank bases,
 - .2 carbon steel "L" sections with epoxy or electrostatic paint finish, for fastening to both the floor structure/housekeeping pad and the equipment base,
 - .3 structure bolt opening equipped with neoprene bushing, compounded to bridge bearing quality,
 - .4 minimum two bolt fastening to equipment base using screws,
 - .5 suitable for equipment direct contact to floor with or without isolation pads,

2.4 Seismic Vibration Isolators

- .1 Type "2-S" – All Direction Neoprene Isolator:
 - .1 ASHRAE Type "E", designed to restrict movement in all directions with no metal-to-metal contact.
 - .2 molded, oil resistant neoprene compounded to bridge bearing quality, with encapsulated cast-in-place top steel load plate, and steel base plate with anchor holes,
- .2 Type "3-S" – Restrained Spring Isolator – Constant Load:
 - .1 ASHRAE Type "B", designed to restrict movement in all directions,
 - .2 colour coded seismic-controlled spring isolator, single or multiple spring coils, with minimum 6 mm (1/4 in.) neoprene pad,
 - .3 removable coil spring element without having to disturb supported equipment,
 - .4 lateral stiffness greater than 1.2 times rated vertical stiffness,
 - .5 minimum 50% overload capacity,
 - .6 non-welded spring elements: epoxy coated, with a minimum 1000-hour rating when tested in accordance with ASTM B-117,
 - .7 steel housing design to limit lateral and vertical movement of the supported equipment,
 - .8 neoprene snubber, to limit maximum equipment movement in any direction to 6 mm (1/4 in.),

- .9 location of snubbers designed to minimize prying action on floor bolts,
- .10 adaptor base suitable sized for larger anchors, when required to suit anchorage capacity.
- .3 Type "4-S" – Restrained Spring Isolator – Variable Load:
 - .1 colour coded seismic-controlled spring isolator, single or multiple spring coils, with minimum 6 mm (¼ in) neoprene pad mounted under spring(s),
 - .2 removable coil spring element without having to disturb supported equipment,
 - .3 lateral stiffness greater than 1.2 times rated vertical stiffness,
 - .4 minimum 50% overload capacity,
 - .5 non-welded spring elements: epoxy coated, with a minimum 1000-hour rating when tested in accordance with ASTM B-117,
 - .6 steel housing design to limit lateral and vertical movement of the supported equipment,
 - .7 top load plate with adjustable and leveling bolts,
 - .8 adjustable vertical restraints to allow unloading of water-bearing equipment,
 - .9 isolation washers,
 - .10 bottom load plate with anchor holes,
 - .11 hot dipped galvanized for outdoor installations,
 - .12 neoprene snubber compounded to bridge veering quality, to limit maximum equipment movement in any direction to 6 mm (¼ in),
 - .13 adaptor base suitable sized for larger anchors, when required to suit anchorage capacity.

2.5 Restraints and Braces for Distribution Services

- .1 Type "SCR" – Cable Restraints:
 - .1 manufactured system consisting of cable, building attachment, and vertical hanger rod reinforcement assembly,
 - .2 field-built assemblies are not acceptable,
 - .3 steel wire strand cables:
 - (a) galvanized steel aircraft cable to ASTM A1023, or stainless steel to ASTM A492
 - (b) sized for seismic load with a safety factor of 2,
 - (c) arranged for restraint in both longitudinal and transverse directions under tension loads only,
 - (d) connector strength rating equal to 90% of cable breaking strength rating.
 - .4 building and equipment attachment brackets:
 - (a) carbon steel assemblies, designed to permit rotation to the final installation angle, or 45° bent steel plates with holes to allow attachment of cable loops,
 - (b) protective loop thimbles at contact with connectors,
 - (c) rope connections: overlap wire "U" clips with at least two (2) bolt fasteners, or, tool-less wedge insert lock connectors,
 - (d) selected to exceed the cable working design load by 50%,
 - (e) single sided "C" beam clamps are not acceptable.
 - (f) fasteners to building structure designed to withstand simultaneous shear and tension loads, including prying action due to the bracket.
- .2 Type "SSB" – Solid Braces:

- .1 factory-built or field assembled solid braces, consisting of structural-shapes, building attachment, and vertical hanger rod reinforcement assembly.
- .2 sized for seismic load with a safety factor of 2,
- .3 arranged for restraint in both longitudinal and transverse directions.
- .4 building and equipment attachment brackets:
 - (a) carbon steel assemblies, designed to permit rotation to the final installation angle, or 45° bent steel plates with holes to allow attachment of cable loops,
 - (b) selected to exceed the working design load by 50%,
 - (c) single sided "C" beam clamps are not acceptable.
 - (d) fasteners to building structure designed to withstand simultaneous shear and tension loads, including prying action due to the bracket.
- .3 Bracing of vertical hanger rods for SCR restraints and SRB braces:
 - .1 hanger rods braced to avoid potential for buckling;
 - (a) structural steel angle or formed channel brace selected to prevent support rod buckling,
 - (b) brace attached to support rod with a series of adjustable clips, without the use of hand-tools.
 - .2 hanger rods are not required where two SRB braces are provided at each seismic restraint location, and are installed at 180° opposition to each other.

2.6 Mechanical Anchors

- .1 General:
 - .1 Post-installed mechanical anchors in concrete to be seismically qualified for installation in cracked concrete in accordance with ACI 355.2 by testing for seismic tension and shear loads in cracked concrete in accordance with ICC-EC AC193, and qualified by an ICC-ES seismic evaluation report.
 - .2 Anchors installed in concrete masonry units to be seismically qualified in accordance with TMS 402/602 by testing for seismic tension and shear loads in accordance with ICC-ES AC01 or AC106, and be qualified by an ICC-ES seismic evaluation report.
 - .3 Anchors to be selected for concurrent shear and tension loads with a safety factor not less than 2.0 times estimated load.
- .2 Undercut anchors for post-concrete installation:
 - .1 zinc-plated carbon steel bolt, nut, washer and cone-shape bearing-bell, with tungsten-tipped cutting radial edges, to create bearing force by keying into concrete,
 - (a) for outdoor use, all materials are to be stainless steel.
 - .2 special undercut stop-drill bit and installation setting tool,
 - .3 marking system to indicate when the anchor is completely installed,
 - .4 designed for pre-setting of anchors and/or fastening of anchors through the equipment attachment opening,

Standard of Acceptance

- ° Hilti - fig. HDA (indoor), HDA-R (outdoor)

- .3 Expansion wedge anchors for post-concrete or masonry unit installation:
 - .1 zinc-plated carbon steel bolt, nut, washer, expanding segments and wedge mandrel, to create restraint force by friction and keying against/into adjacent concrete,
 - (a) for outdoor use, all materials are to be stainless steel.
 - .2 torque- loading to determine complete installation,

Standard of Acceptance

- Hilti - fig. KB-TZ2 (concrete and masonry)
- Hilti - fig. HSL-3 (concrete only)

.4 Screw anchors for masonry units:

- .1 Zine-plated carbon steel masonry screw with hex washer head, to create restraint force by keying into concrete masonry units.
 - (a) for outdoor use, all materials to be stainless steel.

Standard of Acceptance

- Hilti - fig. KH-EZ series.

.5 Housekeeping pad anchors:

- .1 for installation prior to pouring of the housekeeping pad and post-installation of the structural floor,
- .2 tapered ductile iron body, with openings sized for two runs of Ø10mm (#3) reinforcing bar, and body NC threaded receiver for connection to undercut or expanding wedge anchors,
- .3 two pieces of Ø10mm (#3) reinforcing bar, of sufficient length to tie into housekeeping pad reinforcement,
- .4 undercut or expanding wedge anchor for connection to the structural floor slab.

Standard of Acceptance

- Mason Industries - fig. HPA

2.7 Adhesive Anchors

.1 Adhesive anchors for post-concrete installation:

- .1 seismically qualified for installation in cracked concrete in accordance with ACI 355.2 by testing for seismic tension and shear loads in cracked concrete in accordance with ICC-EC AC308.
- .2 to have an ICC-ES seismic evaluation report, and be suitable for installation in cracked and uncracked normal- and light-weight concrete.
- .3 anchors to be selected for concurrent shear and tension loads with a safety factor not less than 2.0 times estimated load.
- .4 injectable, two-component hybrid adhesive, matching threaded rod and accessories.

Standard of Acceptance

- Hilti - fig. HIT-HY 200

3 EXECUTION

3.1 General Requirements

- .1 Design and construct seismic restraints to;
 - .1 keep equipment and distribution services in place during and following seismic events,
 - .2 resist vertical loading simultaneously with transverse or longitudinal seismic loading.
- .2 Give special consideration to design for adjacent connections, insulation treatment, thermal movement, vibration isolation, and relation to building seismic joints.
- .3 Select restraint fastening systems so that full restraint will be provided assuming one failed fastener.

- .4 Install seismic restraint devices in accordance with manufacturer's instructions and Seismic Engineer's installation shop drawings.
- .5 Secure each transverse or longitudinal brace to the building structure, and not any other building service.
- .6 Restraint installation;
 - .1 install cable restraints with cables snug.
 - .2 use solid braces only in rigidly supported situations,
 - .3 brace hanger rods forming a part of a seismic restraint to accept resulting compressive loads,
 - .4 install transverse and longitudinal braces at angles between 45 and 60° measured from the horizontal, unless the seismic bracing details by the Seismic Engineer states otherwise.
- .7 Trapeze supports may have the trapeze braced (transverse and longitudinally) provided each conduit (of all types) or cable is restrained to the trapeze.

3.2 Use of Pre-Engineered Bracing Details for Electrical Distribution Services

- .1 Use of pre-engineered restraint and bracing details for conduit in accordance with SMACNA is permitted. Where the installation of these services exceeds the limits of the SMACNA guideline, provide specific engineering restraint devices and systems.
 - .1 for SMACNA details, refer to the seismic hazard level ("SHL") by floor level in Schedule A of this Specification Section.
- .2 For the purpose of using SMACNA piping restraints, the following table may be used as a conversion for selected galvanized steel conduit and EMT sizes, where they are 40% filled with copper conductors. Use a similar conversion based on an equivalent weight per linear unit basis for other conduit materials and conductor fill quantity.

Galvanized steel conduit Size, I.D. (mm)	53	63	78	91	103	129	155
EMT Size, I.D. (mm)	63	78	91	103	-	-	-
Reference Pipe Size, Schedule 40, NPS (in)	2½	3	3½	4	5	6	8
Unit Weight of Reference Pipe Size Filled with Water Kg/m	11.7	15.9	19.8	24.2	34.6	46.8	74.6

- .3 Provide cable restraints or bracing for transverse and longitudinal seismic restraints at spacing and locations as specified in the above referenced standards.

3.3 Exemptions from Seismic Restraint

- .1 The following electrical distribution services are exempt from seismic restraint:
 - .1 exemption rules in SMACNA for piping apply to the equivalent weight per linear unit of conduit (of all types).
 - .2 conduit Ø60 mm (2.5 in. nominal) and smaller that are suspended, and wireways of similar cross-sectional area.
 - .3 suspended conduit where the length of support from the structure to the conduit does not exceed 305 mm (12 in.) and,

- (a) the connection of the hanger rod to the building structure is fitted with a swivel to prevent bending of the rod,
 - (b) the free movement of the conduit will not come into contact with other building services or the building structure.
- .4 conduit and cables fastened directly to the building structure (excluding partitions) using industry standard clips and concrete anchors as specified herein.
- .2 These exemption rules do not apply to:
 - .1 fire alarm cables and conduit,
 - .2 emergency power cables and conduit,

3.4 Building Structural Connections

- .1 Select building connection devices based on seismic loads for actual equipment purchased.
- .2 For connection to concrete structures:
 - .1 Select building structure anchors as follows:
 - (a) post-installed undercut anchors or wedge-expansion anchors,
 - (b) concrete inserts may be used in new construction but only where complete seismic design is completed and seismic forces are adjusted to suit,
 - .2 Spacing between anchors: not less than 3 x the effective embedment of the greatest embedment length.
- .3 Where adhesive anchors or concrete inserts are used, the anchors are sized for an increased seismic force as described in article "Design Criteria".
- .4 For connection to steel structures:
 - .1 use double sided beam clamp, loaded to the centerline of the beam web, or
 - .2 were permitted by the building structural engineer, specifically designed welded or bolted connection may be used.
 - .3 the use of single sided "C" type beam clamps is not permitted for the connection to the building steel structure for hanger rods and seismic restraints.

3.5 Construction of Housekeeping Pads

- .1 Do not construct housekeeping pads until equipment restraint and anchors are designed and selected by the Seismic Engineer and/or seismic restraint manufacturer, and housekeeping pads detailed design are provided by the Seismic Engineer.
- .2 Provide housekeeping pads with integral reinforcement and structural anchors to the floor slab to withstand applied shear loads and anchor pull-out tension loads.
 - .1 provide reinforcing bar both directions on equal centers, and interior and perimeter floor anchors,
 - .2 in pre-installation construction, "Z-bar" shapes may only be used when housekeeping pad layouts are known prior to construction of the structural floor slab,
 - .3 in post-installations, use tapered housekeeping pad anchor assemblies,
 - .4 in post-installations, "L-rebar" shapes with adhesive anchors may be used, except the seismic forces in Schedule A of this Specification section must be increased as described above for adhesive anchors.
- .3 Pre-engineered details of construction for housekeeping pads as shown in chapter 6 of ASHRAE *Practical Guide to Seismic Restraint* may be used within its defined limits of application including but not limited to:

- .1 housekeeping pad sizes are limited to 37 m² (400 ft²) or less,
 - .2 equipment center of gravity height does not exceed the width of the housekeeping pad,
 - .3 the ASHRAE maximum load rating includes the weight of the restrained equipment, vibration isolation equipment, support rails and bases, and the housekeeping pads,
 - .4 for values of "Fp" in ASHRAE, substitute the horizontal seismic force "Vp" as defined in the National Building Code of Canada for non-structural components (based on the seismic force coefficient "Ks" in Schedule A of this Specification section).
- .4 Size the housekeeping pad so that the distance from the equipment anchors to the edge of the pad is not less than 1.5 times the effective embedment depth of the equipment anchor, unless the anchor manufacturer requires greater separation distance.

3.6 Restraints for Bus Duct, Busway, Cable Tray - General Requirements

- .1 Use braces for restraint of bus ducts and busways.
- .2 Use braces or cable restraints for cable trays.
- .3 Provide reinforcement of hanging rods to prevent buckling of the rod.

3.7 Conduit, Wireway Restraints - General Requirements

- .1 Use cable restraints for suspended conduit and suspended wireway.
- .2 Provide reinforcement of hanging rods to prevent buckling of the rod.
- .3 For trapeze hangers, provide U-bolts over conduit to limit lateral and vertical movement.
- .4 Attach restraints to conduit or conduit hangers, and trapezes.
- .5 Where pre-engineering restraints in accordance with SMACNA are used, the spacing for transverse and longitudinal restraints are to be reduced to 50% of the stated spans for the following conduit materials:
 - .1 PVC conduit.

3.8 Floor Mounted Equipment Restraints

- .1 Anchor floor mounted equipment with anchor bolts, with a minimum of four (4) anchors.
 - .1 friction due to gravity loads shall not be considered to provide resistance to seismic forces.
- .2 Secure equipment directly using equipment base supports or SRB brackets. Alternatively, use type SS1, SS2, SS3 or SRB snubbers where equipment is not subject to overturning moments. Use only type SRB or SS3 snubbers where equipment is subject to overturning moments;
 - .1 for type SS1 snubbers, provide a minimum of eight (8) snubbers for each piece of equipment, with two units placed on each corner of the equipment base frame.
 - .2 for type SRB, SS2 and SS3 snubbers, provide a minimum of four (4) snubbers for each piece of equipment, with one unit placed on each face of the equipment base frame.
- .3 Provide resilient neoprene bushings and washers between equipment and anchor bolts where equipment is secured rigidly to floor or housekeeping pad.
- .4 Install snubber devices only after equipment is installed and operating, to ensure no metal-to-metal contact. Adjust snubbers so that any clearance gaps do not exceed 6 mm (1/4 in.).
- .5 For floor mounted equipment with vibration isolators;
 - .1 select basic vibration isolator in accordance with Section 20 05 48.
 - .2 select seismic restraint for each piece of equipment of either:
 - (a) integrated seismic vibration restraint type 2-S, 3-S or 4-S, or

(b) vibration isolator in accordance with Section 20 05 48 combined with seismic snubbers SS1, SS2 or SS3 as applicable to suit overturning moment.

- .3 Do not mix type of restraint on the same piece of equipment.
- .4 Where the equipment is not provided with a structural base to transfer seismic forces, provide a structural-shape or formed steel channel base as a complete steel frames suitably cross braced in both horizontal directions to withstand seismic induced shear force and bending moments.

3.9 Suspended Equipment Restraints

- .1 Provide restraints for equipment independent of restraints provided on connecting conduit, bus duct, busway or cable trays.
- .2 Provide reinforcement of hanger rods to prevent buckling.
- .3 Provide SCR type longitudinal and transverse restraints at each corner of the equipment (total of eight (8) cables). Alternatively, a single SCR cable can be installed at each corner of the equipment, positioned at 45° to both transverse and longitudinal direction and sized for concurrent transverse and longitudinal loads.

3.10 Equipment Restraints - Surface Wall-Mounted Equipment and Panels

- .1 Application: for electrical panels, control panels, motor controllers, and other electrical distribution equipment.
- .2 Attach equipment to horizontal galvanized steel channels and fasten with bolts equipped with neoprene isolation grommet washers. Channels to extend past the side of the equipment to allow anchoring to wall. Select bolts for concurrent shear dead-weight without deduction for uplift load, and tension restraint load.
- .3 Attach channels to concrete or masonry walls with not less than four (4) anchors with each anchor having a not less than a 1.5 safety factor.

3.11 Equipment Restraints - Recessed Wall-Mounted Equipment

- .1 Application: for electrical panels, control panels, motor controllers, and other electrical distribution equipment.
- .2 Mount recessed equipment through the top, bottom and sides of the equipment housing to adjacent block wall or wall studs.

3.12 Inspection, Testing, Adjustment and Reporting

- .1 For equipment supported on vibration isolators, field measure air gaps on each restraint and if necessary adjust the restraint so that the clearance air gap does not exceed 6 mm (1/4 in.). Provide a written report identifying the results of each test and adjustment, to the Seismic Engineer and Consultant for review.
- .2 Arrange for the seismic restraint manufacturer to inspect and report on the installation at completion of the work. Make corrections of deficiencies identified by the manufacturer. This work is to be performed prior to the final field review by the Seismic Engineer.
- .3 Arrange for Seismic Engineer to conduct a final inspection prior to substantial performance of the Work. Make corrections of deficiencies identified by Seismic Engineer. This work is to be performed prior to the final field review by Consultant.
- .4 Make corrections of deficiencies identified by Consultant.
- .5 Submit the following reports prior to application for substantial performance of the Work, or where applicable, ready-for-takeover of the Work:
 - .1 Seismic Engineer periodic and final inspection reports,

- .2 seismic restraint manufacturer inspection reports,
- .3 Seismic Engineer declaration of general review.

3.13 Schedules

- .1 The following schedules are attached to and form part of this Specification section.
 - .1 Schedule A Seismic Force Coefficients and SMACNA SHL Class

Schedule A –Seismic Force Coefficients and SMACNA SHL Class

Table 1 – Horizontal Seismic Force Factors		
Building Level	Horizontal Seismic Force Coefficient (except fire protection)	SMACNA SHL Class
	K_s	---
Roof	0.06	D
3 rd Floor	0.06	D
2 nd Floor	0.05	D
Ground Floor	0.05	D
Basement	0.05	D

Table 2 – Vertical Seismic Force Factors	
Building Level	Vertical Seismic Force Factor
	K_v
All Floors	0.019

END OF SECTION

IDENTIFICATION FOR ELECTRICAL SYSTEMS

26 05 53

1 GENERAL

1.1 Scope

- .1 Provide identification and warning signs for complete electrical systems as shown.

1.2 Applicable Codes and Standards

- .1 Product standards:
 - .1 CSA C22.2 No. 197 PVC Insulating Tape

1.3 Submittals

- .1 Shop drawings:
 - .1 Submit list of nameplates with proposed wording, prior to engraving.
 - .2 Submit list of labels with proposed wording, prior to printing.
 - .3 Submit representative samples of nameplates, labels and warning signs.

2 PRODUCTS

2.1 Warning Signs

- .1 As required to meet requirements of the Electrical Safety Authority.
- .2 Outdoor signs:
 - .1 fibreglass,
 - .2 minimum size 250 mm x 360 mm (10" x 14").
- .3 Indoor signs;
 - .1 aluminum,
 - .2 baked enamel finish,
 - .3 minimum size 180 mm x 250 mm (7" x 10").

Standard of Acceptance

- Brady
- Seton

2.2 Equipment Identification

- .1 Nameplates for panels and equipment:
 - .1 3 mm ($\frac{3}{8}$ ") thick laminated plastic plates,
 - .2 engraved lettering,
 - (a) first line: 11 mm (7/16 in.) high lettering,
 - (b) second line: 7mm (1/4 in.) high lettering,
 - (c) third line: 5mm (3/16 in.) high lettering,
 - .3 colour coded as follows:
 - (a) black lettering on white background for panels and equipment on normal power,
 - (b) white lettering on red background for panels and equipment on emergency power,

- (c) white lettering on blue background for panels and equipment on UPS power,
- .4 with bevelled edges,
- .5 mechanically attached with self-tapping stainless steel screws.
- .2 Labels for warnings, instructions etc on panels and equipment:
 - .1 printed on white polyester background,
 - .2 7 mm (¼") high letters unless specified otherwise,
 - .3 UV resistant inks,
 - .4 clear polyester over lamination,
 - .5 pressure sensitive adhesive.

Standard of Acceptance

- Brady
- Ideal Industries
- Safety Sign

- .3 Do not commence manufacture of nameplates and labels until wording has been reviewed by the Consultant.

2.3 Wiring Identification

- .1 Colour coded phasing tapes:
 - .1 7 mil poly vinyl chloride,
 - .2 pressure sensitive adhesive,
 - .3 compatible with wire insulation,
 - .4 permanent colour,
 - .5 electrically insulating,
 - .6 UV and moisture resistant,
 - .7 to CSA C22.2 No. 197

Standard of Acceptance

- 3M Scotch 35
- Electro Tape Specialties 103/103C Series

- .2 Wire markers:
 - .1 heat shrink,
 - .2 military grade polyolefin sleeves,
 - .3 permanent printed wire identification.

Standard of Acceptance

- Brady
- Panduit

3 EXECUTION

3.1 Equipment Identification

- .1 Identify electrical equipment with nameplates, directories and labels.

.2 Provide nameplates:

- .1 secure to top exterior of equipment except where indicated otherwise,
- .2 switchboards: indicate name, voltage and ampacity,
- .3 rear of switchboard cubicles or cells: indicate name of cell or cubicle,
- .4 panelboards: indicate name, voltage and source of power,
- .5 terminal cabinets: indicate name, system and voltage,
- .6 circuit breakers with fixed trip units: indicate load supplied, voltage and maximum allowable ampere rating of the breaker,
- .7 circuit breakers with replaceable trip units: indicate load supplied, voltage and maximum allowable ampere rating of the trip unit,
- .8 circuit breakers with adjustable trip units: indicate load supplied, voltage and maximum allowable ampere setting of the long time pick up,
- .9 disconnects: indicate load supplied, voltage, type of fuses and maximum allowable ampere rating of fuses,
- .10 starters: indicate equipment being controlled, voltage and maximum allowable setting of the overload device,
- .11 contactors: indicate equipment being controlled and voltage,
- .12 transformers: indicate name, capacity, primary and secondary voltages,
- .13 pull boxes and junction boxes: indicate system, circuit numbers and voltage,
- .14 cabinets for low voltage systems, such as signals and communications: indicate name and system,
- .15 equipment not listed above, such as, instruments, fire alarm, clock and program equipment and control panels: identify in a similar manner showing name and number of the equipment, voltage and load information.
- .16 typical identification standards:
 - (a) Lighting, Receptacle and Power Panels: each identified with an engraved lamicoid nameplate secured to top interior trim as follows:

LP-4NW-1EA	11 mm (7/16") high lettering
120/208 volts	7 mm (1/4") high lettering
Fed from PP-SBSW-EAA	5 mm (3/16") high lettering

.3 Directories:

- .1 Supply each panelboard with a directory card holder welded to inside of door, complete with a neatly typewritten list showing information as follows:

Panelboard Name LP-4NW-1EA		
Panel Voltage 120/208 Volts		
Circuit Number	Description	Maximum Allowable Rating
1	Lighting Room #34	20 Amps
2	Receptacles Room #34	15 Amps
3	Ice Machine Room #17	30 Amps

4/6	Split Receptacle Room #26	20 Amps
5/7/9	Sub Feed to Receptacle Panel RP-4NW-1EA	60 Amps

- .2 Cabinets for low voltage systems, such as signals and communications: as for panelboards with a directory showing circuit numbers and room locations plus a blank column for "Remarks".
- .3 Cover directory list with a 0.8mm (1/32") minimum thick clear plastic sheet to protect it.
- .4 Warning Labels:
 - .1 circuit breakers where the allowable maximum continuous load is less than the breaker rating or the breaker is not marked with a continuous load rating: provide a label stating:
Caution: maximum continuous load not to exceed XXX Amperes.
 - .2 disconnects where the allowable maximum continuous load is less than the switch rating or the switch is not marked with a continuous load rating: provide a label stating:
Caution: maximum continuous load not to exceed XXX Amperes.
- .5 Pull Boxes and Junction Boxes
 - .1 Identify feeder pull boxes and junction boxes:
 - (a) lettering stamped on brass or aluminum tags,
 - (b) showing the name of the feeder or system,
 - (c) voltage involved,
 - (d) data for both termination points whether equipment or panel,
 - (e) secure tag under box lid screws using steel wire.

3.2 Service Rough-in Identification

- .1 Apply a small dab of paint to inside of each outlet box, pull box and panel as it is installed, using colour code as follows:

Red	Fire Alarm System and Emergency Voice Communication System
Dark Blue	Intercom and Public Address
Dark Green	Telephone and Data Systems
Black	Annunciator and Buzzer System
Grey	Clock System
White	Central Dictation
Orange	Nurse Call
Yellow	Alarm Systems
Pink	Computer Systems
Light Green	TV Systems

- .2 Junction boxes in furred ceilings to have colour identification on both inside and outside.
- .3 As an alternative to applying paint dabs, prepainted conduit/EMT may be used where applicable.

- .4 Colour coding is not required for lighting and power circuits.

3.3 Wiring Identification

- .1 Identify feeders and branch circuit wiring with wire markers;
 - .1 at each end of run,
 - .2 in each junction box,
 - .3 wherever they are introduced into ducts or equipment.
- .2 Identify incoming utility service lines by Red - Phase "A", Black - Phase "B", Blue - Phase "C", with colour coded phasing tape.
- .3 Band buswork in each;
 - .1 switchboard,
 - .2 unit substation cubicle,
 - .3 power panel,
 - .4 lighting and receptacle panel,with colour coded phasing tape as follows:

Red	Phase A
Black	Phase B
Blue	Phase C
White	Neutral
Green	Bond/Ground

- .4 Band feeder and sub-feeder bus and conductors as above.
- .5 Maintain phase sequence and colour coding throughout.
- .6 Connections in equipment to be Phase A, B, C from left to right when viewing from front or accessible direction.
- .7 For control conductors for motors and equipment, schedule and chart marker numbers with corresponding machine numbers and locations and include with Record Drawings and Operation and Maintenance Data.
- .8 Use colour coded wires in communication cables, matched throughout system. Schedule and chart, marker numbers and wire colours with corresponding equipment and include with Record Drawings and Operation and Maintenance Data.

3.4 Conduit and Cable Identification

- .1 Label;
 - .1 incoming service cables,
 - .2 bus ducts,
 - .3 feeder conduits/EMT,
 - .4 feeder cables,
 - .5 communications cables.
- .2 Locate labels as follows;
 - .1 at every end of every conduit, duct or cable run, adjacent to item of equipment serviced,

- .2 on each exposed conduit, duct or cable passing through a wall, partition or floor (one on each side of such wall, partition or floor),
- .3 at intervals of not more than 15 m (50') along every exposed conduit, EMT, duct or cable run exceeding 23 m (75') in length,
- .4 at every access point on concealed conduit, EMT, duct or cable runs,
- .5 visible from 1.5 m (5') above adjacent floor or platform.

3.1 Fire Stopping Identification

- .1 Provide a warning card adjacent to each opening exceeding 25mm (1") in diameter, indicating the following;
 - .1 a warning that the opening is protected by a fire stopping material,
 - .2 the fire stop system used, ULC or cUL,
 - .3 F rating or FT rating,
 - .4 specific fire stop product(s) used,
 - .5 name and telephone number of the contact person should any changes to the fire stopping be required.
- .2 Provide warning labels for each fire stopped penetration as follows;
 - .1 permanently attached to walls, floors, underside of slabs, adjacent to the penetration,
 - .2 on each side of the penetration,
 - .3 vinyl panel, white and red background with black lettering,
 - .4 self adhesive with permanent pressure sensitive adhesive,
 - .5 stating:

WARNING
THROUGH PENETRATION FIRESTOP SYSTEM - DO NOT DISTURB
NOTIFY BUILDING MANAGEMENT OF ANY DAMAGE

3.2 Single Line Electrical Diagrams

- .1 Provide a single line schematic diagram in each Electrical room to illustrate every component including;
 - .1 main service,
 - .2 transformers,
 - .3 grounding,
 - .4 switchgear,
 - .5 unit substations,
 - .6 generators,
 - .7 circuit breakers,
 - .8 fuses,
 - .9 capacitor banks,
 - .10 surge protective devices,
 - .11 disconnect switches,
 - .12 transfer switches,
 - .13 panelboards,

- .14 major items of equipment such as chillers,
- .15 feeders,
- .16 key interlocks,
- .17 interlocking schemes,
- .18 protective relays,
- .19 metering,
- .20 transformer winding arrangements,
- .21 voltage levels, including number of phases and wires,
- .22 equipment ratings such as: Amperes, kW, kVA, kVAR.
- .2 Diagram:
 - .1 print of an AutoCAD drawing using the latest version of AutoCAD,
 - .2 not less than 600 mm x 600 mm (2' x 2'),
 - .3 in a wood frame,
 - .4 plexiglass covered.
- .3 Submit diagram to Electrical Inspection Authority and incorporate all requirements indicated in their comments.
- .4 Submit diagram as shop drawing for review.
- .5 Provide an electronic version of the drawing file to the Owner for the Owner's future use.

3.3 Fire Alarm Diagrams

- .1 Provide at the fire alarm control panel and annunciator;
 - .1 a fire alarm riser diagram,
 - .2 plan diagrams showing fire alarm zoning.
- .2 Diagrams:
 - .1 print of an AutoCAD drawing using the latest version of AutoCAD,
 - .2 not less than 600 mm x 600 mm (2' x 2'),
 - .3 in a wood frame,
 - .4 plexiglass covered.

END OF SECTION

SYSTEM COORDINATION, VERIFICATION AND TESTING

26 08 05

1 GENERAL

1.1 Scope

- .1 The Division 26 contractor shall retain and pay for the services of an Independent Testing Organization ("ITO") to provide System Co-ordination Study, In-plant Inspection, Verification and On-Site Commissioning Service in accordance with the details specified herein.
- .2 The Division 26 Contractor shall include in the Bid Amount the cost for the services of tradesmen to handle equipment, make temporary connections, operate equipment and make repairs and adjustments and assist the testing organization's on-site specialists during the on-site pre-service inspection, testing, calibration, on-site witness testing and supplementary Commissioning phase of the work and as required by the Consultant until the equipment and systems are accepted by the Owner.

1.2 Related Sections

- .1 Without limiting the scope of work or applicability of other specification sections, the work under this section directly integrates with or refers to the following specification sections:
 - .1 26 05 14 Bus Duct
 - .2 26 24 13 Low Voltage Switchboards
 - .3 26 05 27 Grounding - Secondary
 - .4 26 32 13 Power Generation Diesel
 - .5 26 36 23 Automatic Transfer Switches

1.3 Independent Testing Organization

- .1 In order to ensure the requirement for independence, the ITO must be retained directly by the Division 26 contractor. The ITO must not be retained by an equipment manufacturer or their distributor as part of an equipment package.

1.4 Bidding Instructions to Vendors

- .1 The Bidders for Division 26 work shall advise all equipment suppliers bidding for the equipment supply for this project prior to Tender close of the requirement for comprehensive factory and on-site testing and commissioning and the requirement for on-site services of technical representatives during the testing and extensive commissioning phase and ensure the services and associated costs are included in the suppliers' quotations for the equipment for the project and in the Bidder's Tender Price.

1.5 Separate Prices

- .1 Identify in the Bid Form and the Supplementary Tender Form the prices to be added to the Base Bid for the specified services for each of the named acceptable Independent Testing Organizations. Work normal to the electrical trade, miscellaneous materials and handling of electrical components for testing as well as test equipment in accordance with the requirements of the Independent Testing Organization shall be included in the Base Bid.
- .2 The Owner reserves the right to award the Contract for the Electrical Work identified in the Base Bid (i.e. without the Independent Testing Organization Price) prior to final selection of the Independent Testing Organization by the Owner.
- .3 The Owner reserves the right to select any of the named Independent Testing Organizations as the designated sub-contractor to the selected Electrical Contractor for the project without penalty. The

price addition to the Base Bid for the selected organization and declared by the successful electrical bidder will be added to the Base Bid and the final contract will be adjusted accordingly.

- .4 Shortly after closing of the Base Bid, and when requested, the named Independent Testing Organizations shall submit to the Consultant an outline confirming the scope of work, staffing, abbreviated samples of work on similar projects with similar equipment and a list with references of previous similar projects with large UPS and electrical distribution systems, for review and adjudication.

1.6 Approved Testing Organizations

Standard of Acceptance

- Haronitis & Associates Limited
- AC Tesla
- Pelikan
- Eaton Electric / Cutler Hammer Service
- Schneider Canada Service
- Siemens Service
- G. T. Woods
- K-Tek Electro-Service Industries
- Rondar
- Brosz and Associates
- Enkompass

2 PRODUCTS

2.1 Not Used

3 EXECUTION

3.1 Preliminary Co-ordination Study

- .1 Immediately upon award of Contract liaison with the Supply Authority for information on relays and other protective devices installed on their system and substations which affect the co-ordination of this system.
- .2 Include liaison with the equipment manufacturers to obtain appropriate information and to recommend appropriate devices to obtain co-ordination of the system, immediately after award of Contract.
- .3 Prepare preliminary high voltage phase and ground curves and recommend fuse and/or sensor sizes for the main high voltage switchboards.
- .4 For the 600 V Normal, Emergency and APS systems investigate the long time overcurrent settings and determine the correct CT (sensor) size. If multitap CT's are available on the ACB's, select a CT's where the long time setting is middle of the range.
- .5 The recommended relays, sensors and CT's should be documented in a report format and submitted as a shop drawing (8 copies) for review by the Consultant within 2 weeks of award of Contract. The purpose of this report is to allow switchboards to be released to production. Attend all necessary meetings as required by the Supply Authority, Consultant and manufacturer to resolve co-ordination details.

3.2 Detailed Co-ordination Study

- .1 Prepare a detailed co-ordination study of the electrical system and submit 8 copies as a shop drawing for review.

- .2 The co-ordination study shall include the preparation of time-current characteristic curves of the protective devices in the system drawn on special Log-Log graphs with .01 to 10,000 seconds on the Time co-ordinate and 5 ranges on the Current co-ordinate paper. The system shall be sub-divided into portions so that the curve for each device clearly shows its relationship to associated upstream and downstream devices and shall be submitted as per Article "Shop Drawings". Each set of curves on a single graph for the portion of the system involved shall include or show the following:
- .3 Appropriate sections of single line diagram.
- .4 Electrical equipment and conductor damage curves and transformer inrush, damage and overload curves
- .5 Phase and ground time current curves characteristics on different graphs.
- .6 Three phase and ground fault levels when operating with normal utility power. Generator decrement curves for the main emergency switchboard.
- .7 Each protective device identified with a distinctive code matching the ones on the Contract Drawings or alternatively matching ones on a riser especially prepared for the study..
- .8 Separate curves for each different setting of feeder breakers supplying panelboards at each voltage level and on each system, i.e normal power, and emergency power
- .9 Largest downstream non-adjustable device (ie. Moulded case breaker or fuse).
- .10 The co-ordination study shall be submitted in a formal report document as a "Shop Drawing". It shall optimize the setting and selection of protective devices. It shall also identify areas of deviation and note areas of acceptable industry practice.
- .11 The co-ordination study shall include:
- .12 The protective devices on the Supply Authority system
- .13 Main high voltage switchboards.
- .14 Damage curves on cables and transformers
- .15 Distribution equipment at all voltage levels.
- .16 Emergency system and the main distribution related to it.
- .17 Largest protective devices on each power and distribution panels and motor control centres.
- .18 Protection equipment on motors 75 kW (100 HP) and larger.

3.3 Substation Ground Resistivity Study

- .1 Immediately upon award of Contract conduct ground resistivity measurements at the proposed location of the outdoor high voltage substation. In conjunction with the substation drawings, prepare a report for submission to the ESA indicating station ground resistance, ground potential rise, mesh voltage, step voltage, and touch voltage inside and outside the station area. Make recommendations on modifying the substation grounding design where necessary to achieve acceptable grounding system characteristics.
- .2 Verify completed installation as follows:
- .3 Dynamic ground resistance measurements at the high voltage substation using the drop of potential method as described in ANSI/IEEE 81, using a three point (or four point) Fall of Potential multi function tester.
- .4 Dynamic bonding verification of the high voltage switchgear, power transformers, substation enclosure, and associated apparatus using 60 Hz AC excitation current method.
- .5 Buried Grounding System Test

3.4 Lightning Protection and Building Grounding System Testing

.1 Buried Grounding System Test

- .1 Perform electrical measurement testing of the installed combination electrical and lightning protection system buried grounding grid installation to verify the effectiveness of the installation.
- .2 Test using the fall of potential method as described in ANSI/IEEE 81, using a three point (or four point) Fall of Potential multi function tester.
- .3 Inject AC current of non standard (non 60 Hz and non 60Hz harmonics) frequency into the grounding system via an accessible ground lead connection.
- .4 Insert current probe into soil at 10 foot intervals ranging from 0 - 400 feet away from the building, and record resistance.

.2 Connector Contact Resistance Testing

- .1 Perform contact resistance measurements of the following Lightning Protection System connections
 - (a) Each roof mounted LPS air terminal connection to the perimeter roof loop conductor (measure from air terminal to loop conductor)
 - (b) Resistance of bonding connection from each item of equipment on the roof to the roof LPS grid
 - (c) Roof perimeter loop conductor to each LPS down conductor
 - (d) Roof perimeter loop conductor to each roof cross grid conductor
 - (e) Each LPS down conductor bonding connection to the electrical room perimeter ground bars (at each floor level) and to the buried grid stub up conductor
 - (f) Each LPS down conductor joint
- .2 Contact resistance to be measured using digital micro-ohmmeter
 - (a) 0 - 10A or 0 - 100A as required
 - (b) 4 terminal Kelvin measurement type
- .3 Record each measurement in micro-ohms in a chart format identifying each connection type and location

.3 Connections to Buried Grid

- .1 Throughout the perimeter of the ground floor electrical/mechanical plant area, grounding connections between the perimeter copper ground buses and the below grade buried grounding grid are in place.
- .2 Similarly, the LPS down conductors in the computer room areas of the building are routed down the perimeter walls from roof to buried grid
- .3 Measure the effective resistance of each of these connections between the buried grid and the above grade portion by utilizing a two clamp on current transformer measurement technique. One current transformer when clamped around the stub up conductor is to induce a 128 Hz voltage on the conductor, while the second current transformer measures the actual current flowing through the conductor, in order to determine the effective resistance of the connection to the buried grid. The recommended testing instrument for this test is the Fluke / LEM GEO Earth Ground Tester.

.4 Roof Down Conductor Resistance Measurement

- .1 Using the same technique as described above, measure the effective resistance of each LPS down conductor at the roof level, using the Fluke / LEM GEO tester.

3.5 Factory Witness Testing

- .1 Provide in-plant inspection and factory witness testing at various manufacturing plants where the equipment and materials are made and/or assembled prior to shipment to the job-site.
- .2 Certification shall be made that all required tests have been completed and that equipment conforms to standards, specifications and shop drawings and is suitable for shipment.
- .3 Factory witness tests of equipment and HV cables shall be done after equipment have passed standard production tests and is free and clear of deficiencies and in the opinion of the manufacturers, the equipment is deemed suitable for shipment to the job-site.
- .4 The supplementary factory witness tests by the Independent Testing Organization are required to certify on behalf of the contractor and owner that the equipment is compliant and free and clear of deficiencies and suitable for shipment to the job-site.
- .5 The following is an outline of the minimum requirements for the factory witness tests.
 - .1 High voltage cables:
 - (a) High voltage cables:
 - (b) Insulation resistance
 - (c) Compliance with CSA (insulation thickness compliance)
 - .2 High voltage switchgear
 - (a) Physical Inspection
 - (b) Corona Tests
 - (c) Verification of relaying, protection, control and metering schemes.
 - (d) Verification of mechanical and electrical interlocking schemes.
 - (e) Verification of conformity to Ontario Hydro and Supply Authority requirements.
 - .3 Main power transformers
 - (a) Physical inspection of tank, core and coils, (before tanking)
 - (b) BIL tests on all units
 - (c) Heat run tests on all units
 - (d) Ratio, polarity, and phase angle tests
 - (e) Compliance with Specs and Standards.
 - (f) Correctness of upstream and downstream interfaces
 - (g) Proper operation of fan controls and safeties
 - .4 Diesel generators
 - (a) Physical inspection of assemblies.
 - (b) Load tests, per unit and per system
 - (c) Verification of operating performance, protection, relaying, control, metering and load management schemes with ATS simulation.
 - .5 Low voltage switchboards
 - (a) Physical Inspection and compliance with HH Angus specifications and Standards
 - (b) AC Hi-pot tests
 - (c) Verification of protective device functions, ratings and settings in accordance with the approved Co-ordination Study
 - (d) Verification of the proper operation of protection, relaying, control, metering and interlocking schemes.
 - (e) Verification of the auto transfer controls

- .6 Automatic Transfer Switches
 - (a) Physical inspection and compliance with specifications
 - (b) verification of the proper operation of control and interlocking system
- .7 UPS modules and batteries
 - (a) System tests as per UPS specification documents, to be conducted by manufacturer, including heat runs, transients, operating performance, harmonics.
 - (b) Physical inspection and compliance with H. H. Angus specifications
 - (c) Verification of protective device functions, protection, relaying, control, metering, and interlocking schemes.
- .6 Provide a test report for each equipment item in each of above sections. Notify Consultant of failed tests/noncompliance

3.6 Pre-service On-site Inspection, Testing of Equipment and Devices

- .1 Upon Completion of the installation and prior to energization of components and systems, perform a complete inspection and testing to verify phase and polarity match of feeders with equipment and the tightness of power wiring terminations.
- .2 In addition perform the following tests and functions:
 - .1 High voltage cables
 - (a) Phase verification
 - (b) Grounding verification
 - (c) DC Hi-pot
 - (d) DC Hi-pot
 - .2 High voltage switchgear
 - (a) Physical inspection, verification of wiring and interconnections
 - (b) Dynamic contact resistance on bus connections
 - (c) DC hi-pot
 - .3 Power Transformers
 - (a) Thorough physical inspection
 - (b) Verify operation of temperature controls and fan operation
 - (c) Ratio, polarity and phase angle test
 - (d) Insulation power factor and polarization index tests
 - (e) Insulation power factor and polarization index tests
 - (f) Oil samples and oil analysis report for contaminants and insulation quality
 - .4 Emergency Power System including ATS's
 - (a) Diesel generator system
 - (b) Diesel generator system
 - (c) Polarity and rotation tests of power terminations
 - (d) Dynamic contact resistance test on breakers and batteries
 - (e) Infra-red scan on terminations during heat run tests
 - (f) System tests as per specification documents, to be conducted by manufacturer's technical representative.
 - (g) Calibration of protective devices

- (h) Calibration of protective devices
- .5 Low voltage switchboards
 - (a) Thorough physical inspection, verification of wiring and interconnections.
 - (b) Dynamic contact resistance on breakers and bus connections.
 - (c) Mechanical operation of breakers including racking-in and out of housing
 - (d) Calibration of relays, tests and record "as left" condition.
- .6 Power Feeders
 - (a) Thorough physical inspection
 - (b) Insulation resistance of all feeders
 - (c) Polarity and rotation tests of power terminations
- .7 UPS module, battery, static switchboards:
 - (a) System tests as per UPS specification documents, to be conducted by manufacturer, including heat runs, transients, operating performance, harmonics.
 - (b) Physical inspection and compliance with H. H. Angus specifications
 - (c) Verification of protective device functions, protection, relaying, control, metering, and interlocking schemes.
 - (d) Dynamic contact resistance on breakers and bus connections
 - (e) Mechanical operation of breakers including racking in and out of housing
 - (f) Calibration of relays, tests, and record as left condition
 - (g) Thorough physical examination
 - (h) Dynamic contact resistance on battery cell connections
 - (i) Voltage measurements on all cells
 - (j) Infra-red scan of internal power components during on-site heat runs on module
 - (k) Battery capacity test, each string
 - (l) harmonic testing of input and output.
- .8 Potential transformers (throughout all components and systems)
 - (a) Ratio, polarity and phase angle tests
 - (b) Insulation resistance tests
- .9 Current transformers (throughout all components and systems)
 - (a) AC excitation test, (produce saturation curves)
 - (b) Polarity ratio and insulation resistance tests
- .10 Metering and Instruments throughout all components and systems
 - (a) Verify correctness of wiring and operation
- .11 Key Interlocking schemes
 - (a) Verify proper operation and identification of all key interlocking systems throughout all switchboards and panelboards

3.7 Testing, Adjusting and Verification

- .1 Provide factory witness testing to suit delivery schedule of manufacturers. Include a contingency allowance in the cost to re-visit the manufacturers' plants and re-witness Factory Witness tests, should the initial tests fail and repairs and modifications cannot be done to correct deficiencies during the initial testing program.

- .2 Provide necessary test equipment, material, labour and miscellaneous services during the testing, adjusting, verification and commissioning procedure.
- .3 Work normal to the electrical trade such as providing temporary feeders, jumpers and connections, and handling equipment shall be done by the contractor under Division 26.
- .4 Work and technical supervision by manufacturers' technical representatives in the verification, testing and commissioning phase shall be provided and all costs for tradesmen and representatives shall be included in the tender price.
- .5 Verify that all protective device schemes function properly. Conduct circuit breaker trip tests. Apply correct voltage and current to protective devices.
- .6 Verify the performance of the ground fault alarm and protection systems
- .7 Provide cross wattmeter readings or equivalent or any differential and/or directional relay schemes. Verify metering schemes.
- .8 During the testing and verification procedure, conduct supplementary spot checks on selected protective devices in company with representative of the Owner and/or Consultant to adjust and re-test protective devices so that final settings will result in performance in accordance with approved issue of respective co-ordination curve.

3.8 UPS Battery Preparation

- .1 Measure and record all intercell battery connector resistances after installation. The Electrical Contractor is to remove and reinstall any connectors with deficient readings at no additional cost to Owner.
- .2 Arrange for the UPS supplier to equalize charge battery strings in accordance with manufacturer's recommendations.
- .3 Measure and record specific gravity readings for each battery cell one week after equalize charge.
- .4 Measure and record individual cell voltages and half cell voltages for each battery cell one week after equalize charge.
- .5 Measure and record electrolyte temperatures for each battery cell and record room temperature.
- .6 Check electrolyte level for each battery cell and adjust as necessary.
- .7 Verify all interrack, intertier and output cable connections.
- .8 Check all bolts in battery racks for tightness.

3.9 On-site Testing of UPS and Batteries

- .1 The UPS Supplier will conduct an acceptance test in presence of and to satisfaction of the Independent Testing Agent and the Consultant, after completion of installation, but before UPS System is permanently put into service.
- .2 Tests shall include operation of breakers manually and electrically, racking in and out, and checking that meters and relays function properly.
- .3 In addition to above, include work associated with field testing, cleaning and calibration of new relays and trip devices in Bid cost.

3.10 Preliminary On-Site Testing - UPS & Batteries

- .1 After connections have been completed, checkout of all components and preliminary tests have been completed and all deficiencies have been corrected, the Contractor and UPS vendor are to conduct a heat run on the module and system bypass, in the presence of the Independent Testing Agent, and the Consultant.

- .2 The heat run on the module shall be run for 4 hours at full module load using the building test load bank.
- .3 The equipment shall have passed all preliminary and heat run tests before final witness tests in the presence of the Contractor's testing organization and the Owner's Engineer can be conducted. Notify the Consultant when all of the above has been completed. Failure to complete a heat run shall result in a complete retest, once failed components have been replaced.
- .4 Conduct Witness Tests in accordance with the Consultant's test program.

3.11 On-Site Witness Tests and Commissioning Program - UPS & Batteries

- .1 After connections have been completed and preliminary tests have been made, conduct an On-site Witness Tests to the satisfaction of the Consultant. Once these test have proved satisfactory, provide the services of a licensed electrician to participate in the Owner's and Engineer's Commissioning program. The testing and demonstrations required during the Commissioning program will be conducted at a time suitable to the Owner to be on-site during the Commissioning program.
- .2 The UPS Vendor will demonstrate the capabilities of the UPS equipment to provide continuous uninterruptible power under the various power supply conditions claimed by the manufacturer and in particular the following specific conditions:
 - .1 Normal start-up sequence and ability to come on line and share load with a full rated test load, verify modules share load to within $\pm 5\%$.
 - .2 Ability to fine tune the system for float voltage control.
 - .3 The ability of the UPS to supply acceptable power to the critical bus when the incoming power from the utility and emergency system has been disconnected and reconnected rapidly. Record the electrical parameters of the system, i.e. Battery voltage, load voltage, load amps, power factor.
 - .4 Verify input harmonic performance of the UPS system when connected to the Hydro supply and when connected to the various combinations of available generator sources. Verify total harmonic current distortion does not exceed 10%. Monitor input voltage distortion and trap current and voltage throughout the tests and record data. Tests shall be done when connected to hydro and diesel generator. During input harmonic testing, a BMI harmonic analyzer will be supplied by the UPS vendor to perform harmonic current and voltage testing. Filter trap current and voltage shall be monitored to ensure filter is operating within safe limits. In the event that the testing reveals unacceptable harmonic levels or harmonic resonance conditions, manufacture shall retune filter with new components and entire test procedure will be repeated as often as necessary to obtain performance as specified and to the satisfaction of the Consultant, all at no additional cost to the Owner.
 - .5 Manual transfer to and from by-pass without any interruption to the critical bus while carrying: a full system rated test load when being fed from Hydro and from the APS system. Record parameters.
 - .6 Automatic transfer to by-pass without any interruption to the critical bus by overloading inverter cubicles. Record parameters.
 - .7 The ease of trouble shooting and replacement of defective fuses.
 - .8 Alarm and annunciator functions.
 - .9 Transient performance during the various transfer tests noted above shall be monitored using a BMI monitor, with out of tolerance thresholds suitably set to record the disturbance.

3.12 Performance Verification of the Entire System

- .1 After the energization of the electrical systems have been satisfactorily completed and all testing and calibration work have been done and all reports submitted as shop drawings to the Consultant and all deficiencies noted to-dated have been corrected, the systems shall be subjected to supplementary

dynamic simulation and verification of their operating performance characteristics in accordance with the Consultant's Test Plans and in the presence of the Consultant and Owner's representative.

- .2 The Contractor's forces and manufacturer's technicians shall also be present to start, stop and operate equipment and make adjustments as directed by the Consultant.
- .3 The following is an abbreviated outline of the tasks to be undertaken:
 - .1 Dynamic phasing and polarity verification of HV & LV switchboards, automatic transfer switches, and APS systems.
 - .2 Verify the start signal from each ATS is received at the respective diesel generator control panels and that the DG's start and supply power to the ATS's in the prescribed sequence.
 - .3 Verify that APS system will operate automatically. Tripping of incoming power supplies will be required
 - .4 Verify operation of APS automatic load management system by removing generating units from the system and simulating other malfunctions in the system.
 - .5 Verify operation of all manual controls on APS system
- .4 Upon completion of the Commissioning phase, prepare a comprehensive report summarizing the findings.

3.13 Reports

- .1 Prepare and submit the following reports. Simultaneously submit one copy directly to the Consultant and a further 6 copies to the contractor to be processed as a shop drawing:
 - .1 Preliminary Co-ordination Study with breaker and protective device requirements
 - .2 Final Co-ordination Study
 - .3 Factory Witness test report for each item of equipment within 5 working days of the factory visit. Where deficiencies in the factory test have been noted, inform the engineer and contractor immediately to permit a decision to be made whether remedial action is required of the manufacturer prior to the equipment being accepted for shipment to site.
 - .4 Site Testing Report for each item of equipment within 5 working days of completion of site test.
 - .5 Site Performance verification report(s) to reflect each significant phase of system completion.
 - .6 Upon completion of the Commissioning phase, prepare a comprehensive report summarizing the findings.
- .2 The final report and study shall include assurance for the following items:
 - .1 That the protective devices on the high voltage equipment co-ordinate with the Utility protective devices.
 - .2 That the protective devices within the parameters of the study conform to the results of the study.
 - .3 That the equipment has been tested and performs as per the settings of the approved co-ordination curves.
 - .4 That the "as left" condition of the protective devices correspond to the record documents.
- .3 Completed studies and reports shall be submitted simultaneously to the Consultant as well as part of the requirements of the Maintenance Manuals. Provide 5 copies of final reports and co-ordination study.

END OF SECTION

TESTING OF INTEGRATED FIRE PROTECTION AND LIFE SAFETY SYSTEMS

26 08 11

1 GENERAL

1.1 Scope

- .1 Provide testing of integrated fire protection and life safety systems and related equipment provided under Divisions 26 to 28 with those provided under other Divisions of the Work, in accordance with specification section 01 75 11.
- .2 This specification is limited to testing of the interconnections between life safety and/or fire protection systems. Refer to separate technical specification sections for the individual testing and commissioning requirements for those systems.

1.2 Related Sections

- .1 Without limiting the scope of work or applicability of other specification sections, the work under this section directly integrates with or refers to the following specification sections:
 - .1 Section 01 75 11 Testing of Integrated Fire Protection and Life Safety Systems

1.3 Definitions and Abbreviations

- .1 Refer to section 01 75 11.

1.4 Applicable Codes and Standards

- .1 Installation codes and standards:
 - .1 CAN/ULC-S1001 Integrated Systems Testing of Fire Protection and Life Safety Systems

1.5 Qualified Tradesperson

- .1 Refer to section 01 75 11.

2 PRODUCTS

- .1 Not used.

3 EXECUTION

3.1 General Requirements

- .1 Conduct complete and thorough testing and documentation of the systems interface and integration between various FPLS systems provided under Divisions 26 to 28 and those provided under other Divisions of the Work.
- .2 Include all labor and material as required to participate in and implement the integrated FPLS testing process for equipment and systems provided under Division 26 to 28.

3.2 Integrated Test Plan and Procedures - Development

- .1 Participate in the development of the integrated FPLS test plan and procedures in accordance with the requirements of specification section 01 75 11.
- .2 Supply manufacturer's operating and testing instructions to the ITC prior to the development of the integration FPLS test plan.

3.3 Integration Test Plan – Implementation

- .1 Complete related FPLS system testing in accordance with the applicable technical specification sections of Divisions 26 to 28, prior to implementation of integrated FPLS testing. Where testing of such systems inherently test the FPLS system interconnection(s), such testing is not required to be duplicated for the integrated FPLS testing provided the results of the integration test are recorded in accordance with the requirements of the integrated FPLS test plan.
- .2 Prior to implementing any integrated FPLS test,
 - .1 provide written confirmation from each trade contractor under Divisions 26 to 28 of the Work, that their respective FPLS related equipment or systems, or parts thereof, have been installed in accordance with the design and are ready for integrated FPLS testing,
 - .2 where applicable, provide test verification reports from the organization that verified the installation of any FPLS system as required by referenced codes or standards, such as NFPA or ULC.
 - .3 provide a copy of inspection reports from an authority having jurisdiction governing a FPLS system.
- .3 Coordinate with the ITC and provide all necessary resources to implement the integrated FPLS test plan.

3.4 Final Test Results Report

- .1 The final test report will be prepared by the ITC.

END OF SECTION

LOW- VOLTAGE SWITCHGEAR

26 23 00

1 GENERAL

1.1 Scope

- .1 Provide low-voltage switchgear as shown.

1.2 Related Sections

- .1 Without limiting the scope of work or applicability of other specification sections, the BAS system is further described in the following the work under this section directly integrates with or refers to the following specification sections:
 - .1 20 05 49 Seismic Restraint

1.3 Applicable Codes and Standards

- .1 Product standards:
 - .1 CSA C22.2 No. 31 Switchgear Assemblies
 - .2 EEMAC G8-2
 - .3 IEEE C37.13 Standard for Low-Voltage AC Power Circuit Breakers Used in Enclosures
 - .4 IEEE C37.17 Standard for Trip Systems for Low-Voltage (1000 V and Below) AC and General Purpose (1500 V and below) DC Power Circuit Breakers
 - .5 IEEE C37.20 Switchgear Assemblies – Including Metal Enclosed Bus
 - .6 IEEE C37.27 Guide for Low-Voltage AC (635 V and below) Power Circuit Breakers Applied with Separately-Mounted Current-Limiting Fuses
 - .7 IEEE C57.13 Standard Requirements for Instrumentation Transformers
 - .8 NEMA SG-5 Power Switchgear Assemblies
- .2 Where requirements of this Specification exceed those of above mentioned standards, this Specification to govern.

1.4 Seismic Qualification

- .1 Seismically qualify (certify) equipment specified herein to remain operational after being subjected to the design seismic forces assuming a building height factor (NBCC) $A_x = 3.0$ with equipment rigidly mounted, by the shaker table method in accordance with Specification section 26 05 49.

1.5 Submittals

- .1 Submit shop Drawings and product data for products specified herein.
- .2 All drawing and product data provided for the equipment to show equipment as specified and ordered.
- .3 Typical drawings are not acceptable. Reproducible drawings for approval to be supplied.
- .4 Physical Construction Drawings, completely dimensioned, showing:
 - .1 arrangement,
 - .2 plan, front view, and elevation views,
 - .3 required clearances for opening doors and for removing breakers,
 - .4 conduit or cable trays entrance locations and dimensions for both top and bottom entrance,
 - .5 bus bar locations and configurations,

- .6 incoming and outgoing power cable terminator positions,
- .7 field wiring terminal block locations, and all other terminal block locations,
- .8 anchor bolt locations,
- .9 grounding connections,
- .10 weight of equipment.
- .5 Three line diagrams, with ANSI device function numbers used throughout, to show all:
 - .1 instrument transformers,
 - .2 relays,
 - .3 meters and meter switches,
 - .4 other pertinent devices.
- .6 Elementary Diagrams:
 - .1 Elementary (schematic) wiring diagrams to be furnished for the electrically-operated breaker control scheme.
 - .2 Each elementary diagram to show all control devices and device contact, each of which to be labelled with its proper ANSI device function number.
 - .3 Each elementary diagram to show device and terminal block terminal numbers.
- .7 Control switches:
 - .1 Provide control switch development tables.
- .8 Detailed connection (wiring) diagrams showing:
 - .1 detailed connection (wiring) diagrams showing:
 - (a) all wiring within each unit,
 - (b) all interconnecting wiring between units,
 - (c) identification of all terminals, terminal blocks, and wires.
 - .2 clear identification, by some distinguishing method, of all interface wiring to remote devices including but not limited to:
 - (a) leads from external current transformers,
 - (b) trip circuits from remote devices,
 - (c) auxiliary contacts to remote devices,
 - (d) AC control power,
 - (e) separate incoming AC power,
 - (f) spare auxiliary contacts and relay contacts which are to be wired to terminal blocks for future use.
- .9 Provide one additional set of drawings shipped with the switchgear for maintenance use, installed in a suitable permanent drawing pocket inside one of the control cubicle doors.
- .10 Provide nameplates in accordance with "Equipment Identification"; submit nameplate designations for approval.
- .11 Submit co-ordination curves for review.
- .12 Spare parts list:
 - .1 complete spare part list, including parts location diagrams or drawings to be included with the manufacturer's quotation.

- .2 list of priced spare parts which manufacturer recommends should be on hand during start-up and the two year's operation.

.13 Material List

- .1 A material list to be furnished listing the quantity, rating, type, and manufacturer's catalogue number of all equipment on each unit.

.14 Installation, Operating, and Maintenance Instructions

- .1 Installation, operating, and maintenance instructions to cover all the equipment furnished including all protective relays, power fuses, auxiliary relays, etc., and to include characteristic curves of each different protective relay and power fuse.

1.6 Factory Test and Inspection

- .1 Factory verification tests to be performed in the presence of the Consultant, Independent Testing Agent, and the Owner's representative, after completion of assembly in factory and following standard factory testing procedures, in accordance with NEMA and EEMAC Specifications, and as described herein.
- .2 Certified copies of standard production tests to be submitted upon request.
- .3 Tests to include hi-pot testing, operation of breakers, operation of relays, meters and switches.
- .4 Completed switchboard to be connected to a power supply (or multiple power supplies as required) to permit operation of all electrically operated devices including but not limited to switches and pushbuttons, indicating lights, meters, and automatic transfer and breaker interlock schemes to prove that they are wired correctly, that contacts make and break and that all devices and meters perform satisfactorily before shipment of switchboard.
- .5 Test the overcurrent and other protective devices on each breaker to prove that trip unit and breaker function satisfactorily.
- .6 Undertake primary current injection testing of each switchboard for verification of protective schemes. Double ended switchboards to be interconnected at factory to permit complete testing.
- .7 Racking in and out of breakers and manual operation of equipment to be tested to prove that items work freely.
- .8 Verification of key interlock schemes.
- .9 Correct deficiencies noted during the factory test prior to shipment.
- .10 Submit certified copies of successful completion of the above tests prior to shipment of the equipment.

1.7 Approvals and Information

- .1 Manufacturer to not commence final fabrication or erection of equipment until receipt of:
 - .1 reviewed or "Reviewed as Noted" shop drawings from Consultant.
- .2 Manufacturer to supply:
 - .1 information to install and test equipment for complete installation,
 - .2 shop drawings for review, as specified in "Submittals",
 - .3 information for Owner, as specified in "Instruction Manuals".

1.8 Provisions for Handling and Field Erection

- .1 Each shipping split of stationary structures to be furnished with removable lifting angles and/or plates suitable for crane hooks or slings.
- .2 Each shipping split to also be furnished with removable steel channel base plates which will permit using pipe rollers or dollies without damaging the frame steel of the equipment.

1.9 Shipping

- .1 If shipped separately, the power circuit breaker to be individually crated and tagged with its proper unit number and the equipment number of the assembly to which it belongs.
- .2 Relays to be shipped installed in the stationary structures and to be securely blocked and braced to prevent damage during shipment if required.
- .3 Each "shipping section" of stationary structures to be provided with a permanently-attached, readily-visible identification tag bearing the equipment number of the assembly of which it is a part.

1.10 Preparation for Shipment

- .1 Preparation for Shipment to be in accordance with manufacturer's standards, unless otherwise noted. The manufacturer to be solely responsible for the adequacy of the Preparation for Shipment provision employed in respect of materials and application, to provide materials and their destination in ex-works condition when handled by commercial carrier systems.

2 PRODUCTS

2.1 General

- .1 Switchboard and Components manufacturers:

Standard of Acceptance

- Eaton Canada
- Schneider Canada Ltd.
- Siemens Canada Ltd.
- ABB

2.2 Materials

- .1 Low voltage switchboard to be of type, rating and arrangement shown. Rearrangement of components will not be permitted. Equipment to be constructed to fit space allocated and to be a free standing assembly mounted on a concrete pad.
- .2 Where future breakers are indicated, bus, stationary element, control and metering wiring to be supplied such that, at a future date, Owner need buy only draw out element and CT.
- .3 Main bus and switchboard to be drilled and plated and have provision for future extension of additional vertical cells at each end of switchboard.

2.3 Structure and Components

- .1 Free standing, rigid, dead-front enclosure
- .2 Indoor weatherproof construction of non walk-in type to conform with CSA Standard C22.2 No. 94 "Special Purpose Enclosures", Type 3.
- .3 Completely accessible with all bolted connections, lugs for cable connections, terminations for power and control wiring and any other items requiring torquing, infra-red thermal scanning, maintenance, or replacement all visible and accessible from the front or rear, when respective hinged door is opened. It is to be possible to undertake full thermal scanning of each component, bus bar joint and termination while the unit is energized.
- .4 The main structure of cubicles to be fabricated of minimum No. 12 gauge steel plate, smooth finished surfaces, welded together and reinforced where necessary with structural members to provide a rigid and self-supporting structure for heavy-duty industrial use. Vertical sections to be designed for bolting together without misalignment or distortion. Cubicles to be divided into individual compartments extending the full height and depth of its units for effectively isolating equipment and connections.

- .5 Each switchgear shipping section base to be of welded 100 mm (4") channel iron or equivalent construction as certified by manufacturer, to provide a rugged assembly. Such construction to prevent distortion during shipment and installation, and maintain level and alignment throughout its life without additional support by the Owner.
- .6 Doors to have rolled or formed edges with reinforced steel as required to form a rigid frame unit. Rear doors to be of the hinged and bolted type, fully gasketed, minimum No 12 gauge steel plate, opening 135E. Hinges to be concealed adjustable type with removable pins. Bolts to be of the captive type and to have large knurled heads for ease of removal. Front cubicle doors to be fabricated of minimum No. 14 gauge steel plate and to be suitably braced for mounting of meters and instrument switches. Front of each cubicle to be equipped with an overall full height hinged and gasketed formed outer door fabricated of minimum No. 12 gauge steel plate. Door to have T-handle 3 point locking system complete with lock and latch. A lexan viewing window, fully gasketed, to be installed in the upper section of the outer door to permit viewing of the upper metering compartment. Ventilation louvres, if required, to be overhanging drip proof and sprinklerproof type with internal splash guard.
- .7 Each circuit breaker to be housed behind a separate minimum 14 gauge hinged steel inner door painted to match switchgear. Meters and instruments to be mounted in the upper compartment on a 14 gauge minimum, hinged steel panel, painted white, suitable braced for mounting meters.
- .8 Overhanging drip-proof and sprinkler proof louvres to be provided for ventilation of ionized gases from the structure where necessary to maintain a maximum internal air temperature of 15EC. rise above 40EC. ambient temperature.
- .9 Individual breaker compartments to be provided with primary and secondary contacts of silver plated copper. Also provide rails, stationary disconnecting mechanism parts and cell interlocks. The drawout mechanism to hold the circuit breaker rigidly in the fully connected, test, and fully disconnected positions. Interlocks to be provided which will prevent moving the circuit breaker from the fully connected, test, and fully disconnected positions, unless the breaker is open. Interlocks to prevent closing the breaker between any of these positions. Provisions to be made for padlocking the breaker open in any of the positions noted above. Mechanisms to be ruggedly constructed and close tolerances maintained to assure interlocks will not fail due to binding, misalignment or susceptibility to distortion. Mechanical designs to be such as to minimize the number of parts requiring lubrication. The entrance to the primary stationary contacts to be automatically covered by a shutter when a breaker is withdrawn to the test/disconnect position or removed from the cubicle.
- .10 Provision of vertical fire retardant and non-hygroscopic barriers between vertical sections, from bottom to top of switchboard, and from front face to back of switchboard. Barriers to be sealed to prevent passage of ionized gases between vertical sections.
- .11 Each switchgear shipping section base to be of welded 100 mm (4") channel iron or equivalent construction as certified by manufacturer, to provide a rugged assembly. Such construction to prevent distortion during shipment and installation, and maintain level and alignment throughout its life without additional support.
- .12 Lifting angles or channels to be provided on each shipping section.
- .13 Two channels across bottom of each section, to permit rolling or jacking of board.
- .14 Two steel plates or channels, to be grouted into concrete pad, for levelling purposes, for full length of switchboard, for mounting under the base channels noted above
- .15 Channel or angle across top of each section for hoisting purposes
- .16 Removable top plates
- .17 Plated hardware
- .18 Shipping splits must be limited to no more than 1250 mm (4') in width, to permit installation through building corridors.

2.4 Busses

- .1 Main bus work, 3 phase extending through all sections, rated to match main breaker rating and braced to withstand stresses resulting from short circuit current of maximum system fault equal to interrupting rating of main breaker combination. Bus work to be plated copper throughout.
- .2 Buswork ampacity to be based on a current density not to exceed 1000 amps per square inch of cross sectional area.
- .3 Main buswork and other live parts in bus compartment fully insulated by covering throughout with PVC using the heated bar and fluidized bed process or heat shrinkable sleeves to the same CSA requirements as 1000 volt insulated conductors. Bus joints to be covered with moulded snap-on covers with the same insulation level.
- .4 Phase collection and provision of necessary bolts, nuts and washers for bus duct connection
- .5 Secondary bus work as required
- .6 Coloured phase designations for all phases to suit CSA, NEMA and Supply Authority Standards.
- .7 Bus connections from the main bus to feeder and the breakers to be fully rated for the maximum frame size breaker which may be inserted. Vertical riser busses to be rated for the total maximum ampacity of the vertical section.
- .8 Continuous copper ground bus of adequate cross-sectional area to be provided 6 mm x 50 mm (¼" x 2") minimum, extending the full length of the switchgear assembly and securely bolted to the structural members of the enclosure. Equipment requiring ground connections to be connected to this bus using approved pressure indent type solderless connectors. Ground bus to be readily accessible from the rear and to be extended adjacent to cable terminations for grounding of the cable shielding and ground wires. Ground bus to be continuous without joints except at shipping splits, where joint to require a minimum of two bolts. The frame of each housing to be grounded to this bus.
- .9 Joints for busses, interconnections and disconnecting devices to have plating and contact arrangement as per manufacturer's standard unless otherwise noted. Bus connections to be bolted with at least two high strength bolts per lap properly torqued and locked into place.
- .10 All busbar connections to be secured by the use of zinc plated high tensile bolts inserted into zinc plated pressure plates having a minimum depth of 10 mm (13/32"). These pressure plates to provide uniform pressure throughout the joint. All bolts to be tightened with a calibrated torque wrench to a pressure in order of 28Nm for 10 mm (13/32") bolts, 45Nm for 12 mm (½") bolts.
- .11 Where the busbars are drilled the cross section through the bars at the point of drilling the cross sectional area to be capable of taking the full rated current. Busbars to be de-burred and cleaned after drilling and coated on the joint face with conducting grease before assembly.
- .12 Provision for bus extensions for future units to be drilled and plated.
- .13 Bus supports of high strength, flame retardant, track resistant, inorganic, non-hygroscopic Class 130 or better insulation material which to be standoff or fully compartmented type so as to eliminate flat horizontal surfaces and provide extra creepage such that contamination buildup under No. 156 conditions does not jeopardize phase to phase and phase to ground insulation integrity.
- .14 Compression type terminal lugs, cable supports, bus supports and necessary space to be provided in the rear section of the switchgear assembly for the proper termination of outgoing cable or bus. Lugs to be double indent long barrel, Burndy Catalogue No. YA-2N.
- .15 Busway feeder connections to be designed with the same integrity as the switchgear bus and provided with at least 75 mm (3") clearance from any part of the metallic enclosure and 125 mm (5") from rear doors.

2.5 Air Circuit Breakers

- .1 Air circuit breakers to be designed, assembled, tested and to comply with the following standards complete with their latest revisions:
 - .1 power circuit breakers in enclosures to comply with IEEE C37.13,
 - .2 fused power circuit breakers to comply with IEEE C37.13/IEEE 538,
 - .3 trip devices to comply with IEEE C37.17,
 - .4 power circuit breakers with separately mounted fuses to comply with IEEE C37.27/IEEE 331.
- .2 Type tests of circuit breakers to have been conducted by the manufacturer as specified in the above standards. Proof of same with certification that the equipment meets or exceeds these standards to be supplied upon request.
- .3 Short time current ratings of circuit breakers to be as follows:
 - .1 unfused circuit breakers; one half second at the current level equal to the interrupting rating,
 - .2 fused circuit breakers; same as for unfused circuit breakers, exclusive of fuses."
- .4 Air circuit breakers to include the following:
 - .1 draw out construction,
 - .2 manual operation for breakers up to 1600 A frame size, electric operation for breakers 2000 A frame size and larger,
 - .3 isolation of adjacent breaker compartments by steel panels, top to bottom and front to rear,
 - .4 isolation of front breaker section and rear bus section by steel panels,
 - .5 breakers to have solid state selective trips with long time, short time and ground adjustable characteristics, equal to Cutler Hammer Type Digitrip RMS 1150i,
 - .6 the digital trip unit to include local operation display and control with capability for remote display and control including energy monitoring and to be capable of transmitting the following data over a compatible two wire local area network to a central computer for storage and/or print out:
 - (a) individual phase currents and ground current,
 - (b) peak energy demand, present energy demand, energy consumed,
 - (c) breaker status: open/closed/tripped,
 - (d) mode of trip:
 - i) override,
 - ii) instantaneous pick up with "off" position,
 - iii) discriminator,
 - iv) short delay,
 - v) ground fault,
 - vi) long delay,
 - vii) long delay pick-up.
 - (e) trip unit status:
 - i) internal trip command,
 - ii) data memory test,
 - iii) program memory test failure,
 - iv) missing or defective rating plug,
 - v) reserve power flux,
 - vi) response to depressing test.

- (f) Breaker control:
 - i) breaker open,
 - ii) breaker close,
- (g) power Quality and harmonics,
- (h) manual reset "cause of trip" indicators for overload, short circuit and ground fault.
- .7 integral ground fault protection on all breakers. Adjustable up to sizes shown. Provide interposing CT as required to obtain ground fault pick-up settings shown in the schedules.
- .8 ground fault annunciation as specified in Article "Ground Fault Annunciation System"
- .9 six auxiliary contacts for remote annunciation, two for "open", two for "closed" and two for "tripped".
- .10 individual breakers to be equipped with a visual indication of ground fault indication. The integral ground fault protection specified for each breaker to include three coordinated time settings, with the minimum time setting to be 0.20 - 0.25 seconds. Two other, longer term, settings to be included, identified as intermediate and long term. The associated current and time ratings to be applied to the breakers as shown. Provide an auxiliary contact, with wiring to an accessible terminal block to indicate a "breaker tripped" condition, as initiated by the solid state relay.
- .11 ability to remain closed during power outage on supply.
- .12 breakers to be horizontal drawout type, equipped with a stored energy spring mechanism for quick make, quick break, trip free operation. The breaker stored-energy spring mechanism to be designed so that the closing speed is independent of both control voltage and the operator. Breakers to be 3 pole, single throw with a continuous current trip rating as specified and shown on drawings, complete with three independent arc quenchers, closing mechanism, mechanical push trip button, interpole barriers and positive position indicator, so that the position of the breaker is indicated at the front of the compartment. Breakers of like rating to be completely interchangeable. A mechanical interlock to allow only the correct rating breaker to be inserted into the cubicle.
- .13 breakers, where required, to have the spring charging device operating at 120 V AC. 120 VAC shunt trip from a power supply internal to the switchboard to be provided for remote tripping applications, on manual and electrically operated breakers. Power supplies for all breakers to be redundant.
- .14 the breaker levering mechanism to be arranged to prevent racking the breaker between the Connected - Test - Disconnected positions unless the breaker is in the tripped position.
- .15 breakers to be dead front construction, which provides a steel barrier between the operator and live parts when racking the breaker - between the Connected - Test - Disconnected positions, and to be capable of being padlocked in any of these positions, such that it cannot be closed or moved to any other position.
- .16 breakers to be positively grounded to the enclosure prior to being inserted into the 'Test' and 'Connected' positions. In the 'Test' position the primary breaker disconnect contacts to be separated by a safe distance from the line and load contacts. The primary disconnect contacts to be self-aligning and to be positively and securely engaged in the 'connected' position. The contacts to be silver to silver and accessible for inspection.
- .17 the secondary disconnecting contacts, as required, to consist of a rugged self-aligning constant pressure device, with smooth silver plated copper contacts, which supply control circuit connections to the moveable element. It to be fully engaged when the circuit breaker is in the 'connected' and 'test' positions. The contacts to be suitably protected from physical damage and designed so that positive contact pressure is assured during the life of the breaker. Control wiring to be harnessed, protected and kept away from moving parts. Wiring to devices to be provided with sufficient slack to prevent breakage from movement or vibration.
- .18 current limiting fuses, on line or load side of breaker as shown complete with interlocks to prevent fuse withdrawal unless associated breaker is tripped and to prevent breaker from being closed if

one or more current limiting fuses or control fuses are blown. Fuses for breakers larger than 2000 A frame size to be contained in a separate draw-out compartment.

- .19 key interlocks, in an arrangement as shown, complete with lamacoid nameplate at key block and on key with key designation inscribed with 12 mm (1/2") letters.
- .20 cable and/or bus duct terminations as required and as indicated on Drawings.
- .21 each breaker to be equipped with pilot lights: red for breaker closed, green for breaker open. Pilot lights to be heavy duty, oil and water tight, 30.5 mm (1.2") diameter, individual push to test type, wired independently of the trip coil circuit, and mounted on the outer door of the switchboard.
- .22 power supplies of suitable capacity for operation of such items as electrically operated breakers and meters, using HRC fuses for protection of small wiring
- .23 redundant power supplies in each switchboard, of suitable capacity complete with transfer control relay to provide 120 VAC power to operator breakers.
- .24 additional redundant power supply in each switchboard, complete with transfer control relay scheme, to provide 120V control power from each switchboard to a common control bus, to provide redundant back up control power to each switchboard for operation of digital metering systems and communications devices forming part of the Electrical Monitoring system. Wiring is to be terminated at suitable labelled terminal blocks, for field wiring between switchboards by the installing contractor.

2.6 Moulded Case Breaker Section

- .1 Moulded case breaker section to be fabricated and assembled as part of switchboard in an arrangement shown.
- .2 Breaker sections to be protected by an overall hinged and formed outer door.
- .3 Door(s) to be gasketed, with overhanging drip shield, with T-handle 2 point locking system complete with lock and latch, protecting breakers and all other components.
- .4 Breakers to have the following features:
 - .1 bolt-on moulded case circuit breaker: quick- make, quick-break type, for manual and automatic operation,
 - .2 breakers to have bolted type connections,
 - .3 common-trip breakers: with single handle for multi-pole applications,
 - .4 trip free feature,
 - .5 clearly indicated on/off, tripped indications,
 - .6 current, voltage, interrupting rating in accordance with schedule on Drawings,
 - .7 breakers to be individually mounted and to be completely removable from the front without removing cable connections,
 - .8 circuit breakers with interchangeable trips over 150 A,
 - .9 on-off locking device,
 - .10 handle mechanism,
 - .11 thermal Magnetic Breakers to operate automatically by means of thermal and magnetic tripping devices to provide inverse time current tripping and instantaneous tripping for short circuit protection,
 - .12 magnetic instantaneous trip elements in circuit breakers to operate only when value of current reaches setting. Trip settings on breakers with adjustable trips to range from 5 - 10 times current rating,
 - .13 breaker to operate by means of a solid-state trip unit with associated current monitors and self-powered shunt trip to provide adjustable inverse time current trip under overload condition, and

adjustable long time, short time, instantaneous tripping for phase, ground fault and short circuit protection, with individually adjustable time and pick up settings. Ground fault pick up to be adjustable up to match frame rating) 600) 800) 1200) amps. Provide a separate zero sequence current transformer around the outgoing phase conductors for each breaker if necessary to achieve this pick up setting,

.14 65,000 A symmetrical interruption rating at 208 volts.

2.7 Bolted Pressure Switches

- .1 Bolted pressure switches to have the following features and facilities:
 - .1 continuous current rating shown,
 - .2 quick-make, quick-break operating mechanism,
 - .3 3-pole group-operated with external handle,
 - .4 locking provisions for open and closed positions,
 - .5 dead front construction,
 - .6 plated switch contacts,
 - .7 insulators and arc shields as required,
 - .8 door interlock designed to prevent switch from being closed when fuse door is open,
 - .9 Kirk key interlocks, where specified,
 - .10 shunt trip feature and Ground Fault Protection as required by Code,
 - .11 current limiting, Form I, Class L, fuses of size shown.

2.8 Fusible Panelboard Section

- .1 Fusible panelboard section to be fabricated and assembled as part of switchboard in an arrangement shown and complete with fusible sections with the following features:
 - .1 quick-make, quick-break fusible switch units with external operating handles,
 - .2 provision for padlocking in "on" or "off" positions,
 - .3 readily visible switch contacts when switch door is open,
 - .4 designed to accept "J" HRC fuses and to reject standard N.E.C. fuses,
 - .5 Fuses to be provided in every section,
 - .6 modular construction allowing removal and/or inter-changeability without modification to buswork or mounting rails,
 - .7 rating of switches as shown.
- .2 Fusible panelboard sections to be protected by an overall hinged and formed outer door.
- .3 Door(s) to be gasketed, with overhanging drip shield, with T-handle 2 point locking system complete with lock and latch, protecting all components.

2.9 Equipment Identification

- .1 Provide coloured phase designations for all phases to suit CSA, NEMA and Supply Authority Standards.
- .2 Engraved, high quality plastic nameplates with black letters suitably inscribed on white background for cubicle and circuit identification to be provided on front and rear sections.
- .3 Engraved letters to be 12 mm (½ in.) minimum, except 6 mm (¼ in.) minimum height may be provided for meters, relays, switches, signal lights, keys and key blocks, and all other devices.
- .4 Circuit identification inscription data will be furnished to the manufacturer as required.

2.10 Phase Designation

- .1 Coloured phase designations or numbering markings to be readily visible in each bus compartment, current transformer compartment, circuit breaker compartment and line and feeder cable compartment.

2.11 Mimic Bus

- .1 A white mimic bus single line diagram to be rivetted on front of switchboard.
- .2 Run bus through breaker handles and show every piece of equipment on board.
- .3 Symbols used to be industry standards for each device.

2.12 Finish

- .1 Finish equipment as follows:
 - .1 basic rust-inhibiting metal process
 - .2 interior in white
- .2 Exterior to be finished with paint equal to Sherwin Williams ASA# 61, Grey.
- .3 Manufacturer to provide quart of touch-up paint or several pressurized spray cans to touch-up small areas marred during installation.

2.13 Control and Secondary Wiring (Breaker Element and Cubicle)

- .1 Control and secondary wiring to be enclosed in metallic raceway insofar as practical. Wiring to outgoing circuits, at shipping splits and devices mounted in hinged instrument panels, to terminate at terminal blocks.
- .2 Terminal blocks to have numbered points for circuit identification. Terminal blocks to be General Electric Type EB or equal. Terminal blocks for current circuits to be shorting block type.
- .3 Wiring to be type 'TA', 'TBS', or 'SIS', flame retardant #14 AWG size single conductor minimum, stranded, tinned copper, extra flexible type throughout. Wires to be tagged at both ends with permanent plastic sleeve type markers. Insulation to be 600 V, working and 1500 V test.
- .4 Secondary and control wiring within the rear bus compartment to be completely shielded in a protective metal covering as far as practical.
- .5 Cable openings between sections to be protected with bushings to prevent abrasion to cable jackets
- .6 Wiring from bus differential and transformer differential CT's to be minimum #10 AWG.
- .7 Fuse and terminal blocks to be easily accessible. Fuses of the proper type and rating to be supplied by the switchgear manufacturer. Provisions to be made for the installation of control conduits to the switchboard and connections to be brought to a terminal board furnished and installed by the switchboard manufacturer. Fuses to be Class J HRC. DC fuses (one per pole) to be in dead front enclosure.
- .8 Auxiliary wiring checks to be made throughout the manufacture and assembly of the equipment to assure wiring correctness and continuity.
- .9 Final checkout of wiring to be made with the complete switchgear lineup assembly to assure wiring correctness and continuity. Polarity of current and potential transformers and devices to be checked to assure proper functioning of all protective devices and instrumentation.

2.14 Control Devices

- .1 Control and instrument switches to be of the rotary cam-type with dial plates engraved as required
- .2 Breaker control switches to have green and red push to test oil tight indicating lamps.

- .3 Control switches to be Westinghouse Type W2, General Electric Type SBM, I.T.E. type Imperial C77, or equal.
- .4 Meter switches to have "knurled knob" handles. Switches to be General Electric Type SB-1 or equal.
- .5 All control wiring for tripping, closing and control lights to terminate on terminal blocks for wiring to Owner's mimic and control panels.

2.15 Instrument Transformers

- .1 Potential transformers and current transformers required to operate relays, meters and other devices indicated in the drawings and specifications to be coordinated so that the ratio and accuracy are suitable for each individual application, taking into account the burdens imposed. Construction of transformers to conform to ANSI Standards. All terminals to have permanent polarity designations and to be wired accordingly. All applicable requirements of IEEE C57.13 to apply.
- .2 Primary potential bus or cable tap leads to be designed with the same design integrity as the primary bus.
- .3 Both current and potential transformers to be wired through test switches to provide quick and easy multi-circuit testing of switchboard relays, meters and instruments.

2.16 Potential Transformers

- .1 Potential transformers to be housed in a separate compartment in the circuit breaker cubicle or superstructure.
- .2 Potential transformers to be of the 0.3 accuracy class, per ANSI Standards and of sufficient capacity to serve the maximum burden imposed.
- .3 Each potential transformer to be protected with current limiting primary fuses, and to be designed to withstand the basic impulse level of the switchboard.

2.17 Current Transformers

- .1 Current transformers to be easily removable and accessible and of the ring or bar-type.
- .2 Ring-type current transformers to be used where burden and accuracy permit. Primary terminals on bar-type current transformers to be silver plated and rigidly (2 bolt minimum) connected to the bus structure.
- .3 Secondary connections of all current transformers to have provisions for short circuiting when not connected to instruments and to be solidly grounded.
- .4 Current transformers to be capable of carrying at least 125% of CT rating continuously and have a short time rating at least equivalent to that of the switchgear bus. Accuracy class: C100/ 0.6 B-1.

2.18 Operation of the Manual Transfer Scheme

- .1 Each double ended switchboard is equipped with a manual transfer scheme utilizing kirk key interlocks.
- .2 The incoming supply to enter the switchboard via two incoming line cells, separated through a normally open bus tie. Both of the incoming line breakers to be normally closed.
- .3 Provide key interlock such that it to be possible to manually transfer the lines by first opening one breaker and then closing the tie breaker, or vice versa.
- .4 Indicating lights to be provided to indicate the following conditions:
 - .1 Red Light: Breaker closed
 - .2 Green Light: Breaker open
 - .3 Blue Light: Potential available indication.

- .5 All necessary relays, switches and wiring to be included to provide the manual transfer scheme as specified.

2.19 Transient Voltage Surge Suppressors

- .1 Transient Voltage Surge Suppressors (TVSS) to be designed, factory assembled and tested in accordance with the latest applicable EEMAC, CSA, NEMA, UL, IEEE, and ANSI Standards including the following:
 - .1 ANSI / IEEE C62.1, C62.11, C62.41, C62.45
 - .2 NEMA LS 1
 - .3 UL 67, 1449, 1283
 - .4 CSA C22.2
- .2 Units to be CSA approved as a TVSS device.
- .3 Shop drawing submittals to state: UL 1449 clamp voltage ratings, surge ratings per phase and per mode, and noise attenuation characteristics.
- .4 All TVSS devices to be type tested with the Category C3 high exposure waveform, 20 kV, 10 kA, 8 x 20 Φ sec, and be capable of withstanding a minimum of 2500 such surges.
- .5 TVSS devices to be mounted integral to the switchboards they are protecting. Units to be delivered to the switchboard manufacturer's plant and factory installed as part of the switchgear assembly. The Low Voltage Switchboard manufacturer to be responsible for designing the necessary mounting assemblies to incorporate the units into a standard breaker cubicle. The units to be mounted on an internal steel pan, with full ampacity switchboard bus bars brought as close as possible to the unit to minimize the length of the final required bus or cable connection to the unit.
- .6 TVSS units to be equipped with a three pole disconnect switch, and 200,000 A dead front HRC fuses.
- .7 TVSS units to be solid state, bipolar, bi-directional clamping devices. The TVSS to be based on non linear voltage dependant metal oxide varistors. Units which also include polypropylene capacitors, silicon avalanche diodes or selenium cells are acceptable. The units to NOT incorporate gas tubes or spark gaps.
- .8 TVSS units to have a maximum continuous operating voltage (MCOV) of not less than 115% of the nominal system operating voltage.
- .9 TVSS devices to provide suppression elements between each set of phase conductors (L-L), between each phase conductor and ground (L-G) for all three wire resistance grounded switchboards. Solidly grounded switchboards and panels to in addition provide suppression elements between each phase conductor and neutral (L-N), and between neutral and ground (N-G).
- .10 Suppressors to have the following single pulse 8 x 20 Φ sec surge current capacity:
 - .1 L-L 200,000 A
 - .2 L-G 200,000 A
 - .3 L-N 200,000 A
 - .4 N-G 200,000 A.
- .11 Each TVSS to include EMF / RFI noise filtering elements providing the following minimum attenuation as measured by the 50 Ω Insertion Loss Method.
 - .1 100 kHz 34 dB
 - .2 1 MHz 51 dB
 - .3 10 MHz 54 dB
 - .4 100 MHz 48 dB

- .12 UL 1449 suppression voltage ratings on individual units to be as follows:
 - .1 120/208V, 4W - 400V L-N, L-G, N-G
 - .2 277/480V, 4W - 800/1000V L-N, L-G, 800V N-G
 - .3 600V, 3W - 2000/2500V L-L, L-G
 - .4 600V, 4W - 2000/2500V L-N, L-G, N-G
- .13 Each TVSS unit to include local display unit complete with:
 - .1 indicating lights to display unit status,
 - .2 audible alarm
 - .3 transient disturbance counter,
 - .4 power quality monitoring providing sag, swell, outage, and surge counters, event storage
 - .5 NO/NC form C dry contacts indicating failure of the suppression network, wired to accessible terminals on the switchboard for extension to the Building Automation System.
- .14 Acceptable manufacturers: (Note: Listing of a manufacturers name does not indicate acceptance of the manufacturers standard product line. The above specification requirements must be met for the product to be accepted. Low Voltage switchgear supplier to ensure TVSS supplier is in compliance)
 - Current Technology
 - Cutler Hammer
 - Liebert

2.20 Meters on Main Breakers

- .1 All meters to be a maximum of {2 m (6'-0")} above floor level with switchboard on {100 mm (4")} pad.
- .2 Provide metering as follows for main breakers:
 - .1 three (3) current transformers and 3 HRC fused potential transformers, metering accuracy, frequency response 10 - 10,000 Hz,
 - .2 digital microprocessor based metering system to be as follows; Westinghouse -Type IQ Analyser or Square D Power Logic:
 - (a) the digital metering to consist of a single microprocessor based unit capable of monitoring and displaying,
 - (b) AC amperes, AC voltage, Watts, Vars, Power Factor, Frequency, Watt Demand, Watt Hours, power quality, harmonics, waveform capture,
 - (c) the digital metering to have an accuracy of 0.5% of the read values,
 - (d) communications with central electrical monitoring system,
 - (e) the digital meter to have a membrane type display face suitable for EEMAC 3R and 12 mounting,
 - (f) the digital meter to be provided with an addressable communication card capable of transmitting all data, including trip data over a compatible two wire local area network to a central personal computer for storage and/or print out,
 - (g) include a centralized monitoring unit, Cutler Hammer "Breaker Interface Module", or Siemens or Square D equivalent in each switchboard, factory connected to monitor the complete status of each breaker in the switchboard,
 - (h) digital meters and monitoring units to be completely programmed and made operational by the Switchgear manufacturer.

2.21 Miscellaneous

- .1 Provide the following:
 - .1 power supplies of suitable capacity for operation of such items as electrically operated breakers and meters, using HRC fuses for protection of small wiring,
 - .2 supply four counterbalanced hoists on wheels with swivel boom, heavy duty winch with positive locking safety latch and lockable wheels, one for each normal and emergency switchboard room,
 - .3 one set of spare fuses per switchboard of each type used in each switchboard,
 - .4 redundant power supplies of suitable capacity complete with transfer control relay to provide 120 VAC power to shunt trip operators on feeder breakers.

2.22 Co-ordination

- .1 Manufacturer to review line and load side equipment connected to switchboard, as well as equipment enclosed and provide trip devices to co-ordinate with line side and load side equipment. Allowance will not be made, after Contract award, to change trip devices to provide satisfactory co-ordination.

3 EXECUTION

3.1 Installation

- .1 Provide low voltage switchboards of type, rating and arrangement as shown.
- .2 Provide a 100 mm (4") reinforced concrete pad with bevelled edges. Seal with paint or concrete sealer to prevent concrete dust from entering equipment. Pads to be provided under this division.
- .3 Grout a minimum of two steel plates with anchor bolts into pad, for levelling purposes, for full length of switchboard.
- .4 Assemble all shipping sections and level switchboard on pad.
- .5 Provide interconnecting, incoming and outgoing cable, bus duct, and control wiring connections as shown and as required.
- .6 Terminate all power cables with two hole long barrel compression connectors equal to Burndy YA-2N.
- .7 Provide grounding of each switchboard to perimeter ground bus with two separate runs of a #4/O green insulated copper in conduit. Terminate with Burndy YA-2N lugs.
- .8 Install 2- #10 AWG in {19 mm ($\frac{3}{4}$ "}) conduit between normal and emergency switchboards for control power interconnection, for proper operation of centralized metering system devices.
- .9 Touch up small areas marred in transit or during installation with touch up paint. Repaint entire switchboard using electrostatic process where large areas of significant damage to factory finish has occurred.
- .10 Provide and install new rubber mats 3' wide 1/4" thick 17,000 volt rating, American Biltrite Canada Ltd., in front and rear of Switchboards for a continuous and neat appearance. Do not place mats until work is completed and room has been thoroughly cleaned. Clean or replace any existing mats dirtied or damaged during the installation.

3.2 On-site Testing

- .1 Conduct an acceptance test in presence of and to satisfaction of Consultant, after completion of installation, but before switchboard is permanently put into service.
- .2 Test to include operation of breakers manually and electrically, racking in and out, and checking that meters and relays function properly. Correct defects at no additional cost to Owner. Replace defective equipment immediately with new factory equipment.

- .3 In addition to above, include work associated with field testing, cleaning and calibration of relays and trip devices in Bid cost.

END OF SECTION

LOW-VOLTAGE BUSWAYS

26 25 13

1 GENERAL

1.1 Scope

- .1 Provide busways and fittings, plugs, supports for voltages 600 VAC and less, as shown.

1.2 Related Sections

- .1 Without limiting the scope of work or applicability of other specification sections, the work under this section directly integrates with or refers to the following specification sections:
 - .1 26 05 29 Fastenings and Supports.
 - .2 26 05 48 Vibration Isolation
 - .3 26 05 49 Seismic Restraints.
 - .4 26 05 53 Equipment Identification

1.3 Applicable Codes and Standards

- .1 Product standards:
 - .1 CSA C22.2 No. 27 Busways

1.4 Seismic Qualification

- .1 Seismically qualify (certify) equipment specified herein to remain operational after being subjected to the design seismic forces assuming a building height factor (NBCC) $A_x = 3.0$ with equipment rigidly mounted, by the shaker table method in accordance with Specification section 26 05 49.

1.5 Submittals

- .1 Shop Drawings:
 - .1 Submit shop drawings and product data in accordance with Section 26 01 01 Electrical General Requirements.
 - .2 Nameplates: in accordance with Section 26 05 53.
 - .3 Indicate in detail, exact routing of bus ducts throughout building and in relation to column lines and structural slabs and walls.
 - .4 Prepare drawings in Revit or alternative approved 3D modelling CAD program.
- .2 Provide voltage drop test results for each size of bus duct.
- .3 Operation and Maintenance Data:
 - .1 Provide operation and maintenance data for incorporation into manual specified in Section 26 01 01 Electrical General Requirements.
- .4 Maintenance Materials:
 - .1 Provide maintenance materials as required and as specified in Section 26 01 01 Electrical General Requirements.
- .5 Operating and Maintenance Instructions:
 - .1 Provide operating and maintenance instructions as specified in Section 26 01 01 Electrical General Requirements.

1.6 Quality Control

- .1 Manufacturer's Production Test and Records:
 - .1 submit certified copies of reports of manufacturer's production testing for bus duct, accessories and plug in units.
- .2 Site Acceptance Testing:
 - .1 refer to Part 3 Execution, for requirements.

2 PRODUCTS

2.1 General

- .1 Certified to CSA standard C22.1 No. 27.
- .2 CSA listed: for Ampacity, Voltage and withstand ratings shown and specified.
- .3 CSA listed: for manner and location in which it will be mounted.
- .4 Voltage rating: to match or exceed system voltage rating.
- .5 Ampacity rating: as shown, applicable for every location of the bus duct and for every mounting arrangement.
- .6 Maximum temperature rise: not to exceed 55°C above 40°C ambient when operating at continuous rated load.
- .7 Insulation: NEMA Class B rated (130° C) insulation system.
- .8 Hardware: plated, corrosion resistant.
- .9 Joints:
 - .1 single thru bolt type,
 - .2 with conical washers and pressure plates,
 - .3 bolt to be in electrical contact with grounded enclosure,
 - .4 totally metal enclosed design,
 - .5 IP 54 or better for indoor installations,
 - .6 CSA type 3R for outdoor installations,
 - .7 silver or tin plated bus contact surfaces.
- .10 Joint bolts:
 - .1 high strength steel,
 - .2 double head type, top head to shear off when correct torque reached, with warning label that drops off with top head.
- .11 Seismically certified to withstand the ground acceleration criteria and seismic demand requirements for non-structural equipment as specified in the Building Code for the geographic location of the installation.
- .12 Coordinate bus duct terminations with switchgear and transformer suppliers and other equipment suppliers as applicable.

2.2 Feeder Bus Duct

- .1 Low reactance type.
- .2 Totally enclosed sandwich type construction.

- .3 Bus enclosure: aluminium.
- .4 Enclosure reinforcement: aluminium or steel side channels.
- .5 Enclosure rating:
 - .1 IP 54 or better for indoor installations,
 - .2 CSA type 3R for outdoor installations.
- .6 Bus bars: silver coated copper.
- .7 Neutral (where indicated): full capacity.
- .8 Bonding type; integral .
- .9 Integral bonding: aluminium enclosure to act as a bonding conductor.
- .10 Integral bonding rating: not less than 50% of the phase conductor rating.
- .11 Harmonic current rating: suitable for continuous loads with harmonic current content of: up to 35% THD.
- .12 Short circuit withstand rating: not less than the available fault level shown at the supply end of the bus duct run for 3 cycles.
- .13 If necessary oversize the bus duct in order to meet the required withstand and harmonic current ratings.

2.3 Fittings

Fittings to be compatible with, to be of the same construction as and have the same ratings as the bus duct sections, including;

- .1 elbows,
 - .2 double elbows,
 - .3 tees,
 - .4 offsets,
 - .5 expansion fittings,
 - .6 end closures,
 - .7 wall, roof, floor flanges,
 - .8 fire stops,
 - .9 flanged ends,
 - .10 cable tap boxes,
 - .11 end cable tap boxes (feed in),
 - .12 center cable tap boxes (feed in),
 - .13 phase transition sections,
 - .14 service heads,
 - .15 transformer taps,
 - .16 transformer connection boxes,
 - .17 transformer flexible connections,
 - .18 bus bar extensions,
 - .2 Wall and floor flanges to be fire rated with a rating not less than the rating of the wall or floor penetrated.
 - .3 Fittings that connect to other equipment to be compatible with the other equipment.
 - .4 Co-ordinate the design of fittings with the manufacturers of connected equipment such as:
- Issued For Bid and Permit

- a. switchgear,
- b. transformers,
- c. panelboards,
- d. generators,
- e. UPS systems,
- f. motor control centres.

2.4 Support

- .1 Supports, including:
 - .1 flatwise hangers,
 - .2 edgewise hangers,
 - .3 vertical hangers,
 - .4 vertical spring hangers,
 - .5 sway brace collars,to be compatible with the bus duct and to be the product of the bus duct manufacturer.
- .2 Where seismically rated bus duct is required, supports to be seismically rated to match.
- .3 Finish supports to match finish of bus duct.

2.5 Finish

- .1 Rust-inhibiting metal treatment process,
- .2 Powder coat finish to UL50 3R,
- .3 Colour: ANSI #61 grey
- .4 Provide 2 pressurized spray cans of matching paint to touch-up small areas marred during installation.
- .5 Finish of bus duct to match finish of switchboard where bus duct is shown connected to a switchboard.

2.6 Equipment Identification

- .1 Provide equipment identification in accordance with Section 26 05 53.
- .2 Indicate name of load served on size 4 nameplate.

Standard of Acceptance

- Schneider Electric
- Eaton
- Siemens
- General Electric

3 EXECUTION

3.1 General

- .1 Provide components such as hardware, hangers, fittings, as necessary, for a complete functioning system.
- .2 Store bus duct and fittings at site continuously in warm dry clean locations.
- .3 Protect contact surfaces of joints from exposure to moisture, concrete dust and any other contaminant.

- .4 Replace bus duct and fittings if
 - .1 they have been roughly handled,
 - .2 joints are damaged,
 - .3 contact surfaces are marked,
 - .4 contact surfaces are contaminated,
 - .5 contact surfaces are corroded,
 - .6 plating is damaged in any way.
- .5 Coordinate bus duct routing with mechanical trades to avoid interferences.
- .6 Coordinate bus duct routing with Construction Manager and provide openings in:
 - .1 walls,
 - .2 floors,
 - .3 roofs.
- .7 Arrange and pay for 4" concrete curbs where ducts rise through floor slabs.
- .8 Curbs to be compatible with fire rated flanges.
- .9 Provide access panels for bus duct installed in ceiling spaces.

3.2 Installation

- .1 Do not install bus duct until that portion of the building is enclosed and dry.
- .2 Install bus ducts, fittings, supports and plug in units in accordance with the manufacturer's instructions.
- .3 For fastenings and supports that are not supplied by the bus duct manufacturer, provide fastenings and per Section 26 05 29 Fastenings and Supports.
- .4 Provide seismically rated supports per Section 26 05 49 Seismic Restraints.
- .5 Support horizontal runs on 1.5 m (5'-0") centres.
- .6 Where supports are attached to structure that supports vibration producing equipment, provide vibration isolation per Section 26 05 48 Vibration Isolation.
- .7 Support vertical runs of bus duct:
 - .1 with a vertical hanger on the lowest floor of the riser,
 - .2 with a vertical spring hanger on each floor above the lowest floor of the riser,
 - .3 with additional supports as required for the weight of the riser.
- .8 Where a riser is high enough to require an expansion fitting, provide a vertical hanger on the floor above the expansion fitting.
- .9 Adjust spring hangers so that they assume a uniform load.
- .10 Provide expansion joints:
 - .1 at intervals as recommended by the bus duct manufacturer, to prevent any damage to or buckling of the bus duct due to expansion,
 - .2 where a bus duct crosses a building expansion joint.
- .11 Provide fire rated flanges where a bus duct penetrates a floor slab or a rated wall.
- .12 Provide a wall flange where a bus duct penetrates non-rated walls.
- .13 Provide phase transposition sections as necessary to maintain consistent phase orientation between source and load.

- .14 Terminate bus ducts properly at associated equipment.
- .15 Where equipment to which the bus duct is connected produces vibrations, including:
 - .1 engine driven equipment,
 - .2 motor driven equipment,
 - .3 transformers,
 - .4 UPS equipment,provide vibration isolation at the connections to the equipment.
- .16 Provide flanges to terminate bus duct at equipment.
- .17 Connect bus duct flanges to equipment buswork using bus bar extensions supplied by the bus duct manufacturer. Coordinate with equipment suppliers.
- .18 Seal and fire stop openings after installation to maintain fire ratings.
- .19 Tighten joints in accordance with the manufacturer's instructions.
- .20 Verify that every joint has been tightened and record the verification. Submit the verification report. Verify phase rotation and polarity, correct any deficiencies.
- .21 Install joint covers after infrared testing and torquing are completed.
- .22 Install bus plugs.
- .23 Provide class J fuses in fusible switch bus plugs, per Section 26 28 13.
- .24 Complete testing of bus ducts per Section 26 08 05, System Co-ordination, Verification and Testing.
- .25 Megger each bus duct in an approved manner before it is energized.

END OF SECTION

GROUND FAULT EQUIPMENT PROTECTION

26 26 13

1 GENERAL

1.1 Scope

- .1 Provide ground fault equipment protection as shown.

1.2 Related Sections

- .1 Without limiting the scope of work or applicability of other specification sections, the work under this section directly integrates with or refers to the following specification sections:
 - .1 26 24 16.13 Power Panels
 - .2 26 28 16.13 Enclosed Circuit Breakers

1.3 Submittals

- .1 Submit shop drawings and product data in accordance with Section 26 05 01 Electrical General Requirements.
- .2 Ground fault protective equipment: product of one manufacturer.

2 PRODUCTS

2.1 Equipment

- .1 Provide ground fault protection on 1200 A, 347/600 V and/or 2000A, 120/208V, 4 wire, 3 phase service.
- .2 Ground fault unit to contain:
 - .1 ground sensing relay suitable for operation at 1200 A factory set. Control voltage: 120 V.
 - .2 three-position sensitivity control switch to select value of leakage current at which relay will operate.
 - .3 indicating lamp illuminated when no ground fault exists, extinguished on ground fault or test.
 - .4 switches:
 - (a) SPDT contacts for alarm and trip,
 - (b) mechanical target indication,
 - (c) manually reset,
 - (d) reset button for contacts and target.
 - .5 suitable for panel mounting.
- .3 Zero sequence transformer toroidal type with 1200 A to 5 amps range.
- .4 System to operate on time delay of 0 to 1 second adjustable at ground current setting.

2.2 Fabrication

- .1 Install the following components in equipment specified in other Sections and as indicated:
 - .1 zero sequence transformer.
 - .2 ground fault relay.

2.3 Related Equipment

- .1 Shunt trip main breakers to Specification section 26 23 00.

- .2 Shunt trip main breakers to Specification section 26 28 16.13.

3 EXECUTION

3.1 Installation

- .1 Do not ground neutral on load side of sensor.
- .2 Install phase conductors including neutral through zero sequence transformer.
- .3 Install ground fault protection system.
- .4 Make connections as indicated and in accordance with manufacturer's recommendations.

3.2 Field Quality Control

- .1 Perform tests in accordance with Section 26 05 01 - Electrical General Requirements.
- .2 Arrange and pay for field testing of ground fault equipment by independent testing agency laboratory, ground fault equipment manufacturer and contractor before commissioning service.
- .3 Submit report of tests to Engineer and certificate that system as installed meets criteria specified.
- .4 Demonstrate simulated ground fault tests.

END OF SECTION

WIRING DEVICES

26 27 26

1 GENERAL

1.1 Scope

- .1 Provide wiring devices as shown.

1.2 Related Sections

- .1 Without limiting the scope of work or applicability of other specification sections, the work under this section directly integrates with or refers to the following specification sections:
 - .1 26 05 53 Identification for Electrical Systems.

1.3 Applicable Codes and Standards

- .1 Product standards:
 - .1 CSA C22.2 No. 111 Switches.
 - .2 CSA C22.2 No. 42 Receptacles.

1.4 Submittals

- .1 Submit shop drawings for each type and size of device.

2 PRODUCTS

2.1 Nameplates

- .1 Wall mounted:
 - .1 engraved laminated plastic to Section 26 05 53.
 - .2 7 mm (1/4") high letters unless indicated otherwise.
- .2 Receptacle mounted:
 - .1 permanently printed on white polyester background,
 - .2 7 mm (1/4") high letters unless indicated otherwise,
 - .3 UV resistant inks,
 - .4 clear polyester over lamination,
 - .5 pressure sensitive adhesive.
- .3 Colours:
 - .1 normal power: black lettering on white background,
 - .2 emergency power: red lettering on a white background,
 - .3 "NOT FOR PATIENT CARE": white lettering on green background.

2.2 Switches

- .1 Features:
 - .1 20 A, 120 V, general purpose AC type,
 - .2 higher ratings where indicated,
 - .3 listed to CSA 22.2 No. 111.

- .4 fully rated for:
 - (a) tungsten filament lamps,
 - (b) fluorescent lamps,
 - (c) inductive loads,
- .5 HP rated where used in motor circuits, with rating not less than the motor HP,
- .6 industrial/specification grade,
- .7 Decora style in finished areas, toggle handle type in unfinished areas,
- .8 silent operation,
- .9 terminals rated for No. 10 AWG wire,
- .10 suitable for back and side wiring,
- .11 silver alloy contacts,
- .12 single pole, double pole, three-way, four-way switches as indicated.
- .2 Toggle colours:
 - .1 Normal power: white.
 - .2 Emergency power: clear.
- .3 Decora rocker colour: white.
- .4 Switches of one manufacturer throughout project, unless accepted otherwise.

Standard of Acceptance

- Pass & Seymour (Legrand)
- Hubbell
- Bryant Electric
- Eaton Wiring Devices (Arrow Hart)
- Leviton

- .5 Switches controlling lights on 120 volt power circuits:

Standard of Acceptance

Type	Catalogue Numbers				
	Hubbell (Toggle) / (Decora)	Bryant (Toggle) / (Decora)	P & S (Toggle) / (Decora)	Eaton (Toggle) / (Decora)	Leviton (Toggle) / (Decora)
Single Pole	1221 / DS120	4901 / -	PS20AC1 / 2621	AH1221 / -	1221-2 / 5621-2
Double Pole	1222 / DS220	4902 / -	PS20AC2 / 2622	AH1222 / -	1222-2 / 5622-2
Three-Way	1223 / DS320	4903 / -	PS20AC3 / 2623	AH1223 / -	1223-2 / 5623-2
Four-Way	1224 / DS420	4904 / -	PS20AC4 / 2624	AH1224 / -	1224-2 / 5624-2

- .6 Switches controlling lights on 347 volt power circuits:

Standard of Acceptance

Type	Catalogue Numbers				
	Hubbell (Toggle) / (Decora)	Bryant (Toggle) / (Decora)	P & S (Toggle) / (Decora)	Eaton (Toggle) / (Decora)	Leviton (Toggle) / (Decora)
Single Pole	HBL18201CN / -	-	PS371510 / 2601347	AH18201 / 7601- 347	18201 / 5691-C
Double Pole	- / -	-	- / -	AH18202 / -	18202 / -
Three-Way	HBL18203CN / -	-	PS371530 / 2603347	AH18203 / 7603- 347	18203 / 5693-C
Four-Way	HBL18204CN / -	-	- / -	/ 7604-347	18204 / 5694-C

- .7 Switches controlling lights on 120 volt emergency power circuits: lighted handle, light to be on when load is off:

Standard of Acceptance

Type	Catalogue Numbers				
	Hubbell	Bryant	P & S	Eaton	Leviton
Single Pole (Toggle) (Decora)	HBL1221IL DS120IL	4901GL -	PS20AC1-SL 2625	AH1221LT -	1221-LH 5631-2
Three-Way (Toggle) (Decora)	HBL223IL DS320IL	4903GB -	PS20AC3-SL 2626	AH1223LT -	1223-LH 5633-2

- .8 Pilot light switches: red pilot light to be on when the load is on:

Standard of Acceptance

Type	Catalogue Numbers				
	Hubbell	Bryant	P & S	Eaton	Leviton
Single Pole (Toggle) (Decora)	HBL1221PL DSL120PL	4901PL-120 -	PS20AC1-PL 2629	AH1221PL -	1221-PL 5628-2

- .9 Weatherproof switches: equal to those above, complete with:

- .1 weatherproof box,
- .2 "While-In-Use" weather protective cover:
 - (a) polycarbonate material,
 - (b) clear lockable cover,
 - (c) attached gasket,
 - (d) stainless steel hardware,

Standard of Acceptance

- Pass & Seymour No. WIUC10
- Hubbell Taymac No. MM410CCN

- .10 Weatherproof switches: equal to those above, complete with:

- .1 weatherproof box,
- .2 "While-In-Use" weather protective cover:

- (a) cast material,
- (b) lockable cover,
- (c) attached gasket,
- (d) stainless steel hardware,
- (e) extra duty.

Standard of Acceptance

- Pass & Seymour No. WIUCAST1
- Hubbell Taymac No. MX3200CN

2.3 Occupancy / Vacancy Sensors

- .1 Neutral required dual technology wall switches: 20 ampere, 120 volt:

Standard of Acceptance

Type	Catalogue Numbers						
	Leviton	Hubbell	Eaton	P & S	Bryant	Watt-stopper	Lutron
Single Relay	OSSMT-TMW	AD2000-1	OSD10N	WDT100	MSD2000-1	DSW-100	MS-B102
Double Relay	-	AD2000-2	OSD10DN	WDT200	MSD2000-2	DSW-200	MS-B202

- .2 Neutral required dual technology wall switches: 15 ampere, 347 volt:

Standard of Acceptance

Type	Catalogue Numbers	
	Leviton	Wattstopper
Single Relay	OSSMT-M3W	-
Double Relay	-	DSW301-347

2.4 Astronomical Timers

- .1 Astronomical timer wall switch for exterior lighting: 15 ampere, 120 volt.

Standard of Acceptance

- Wattstopper RT200
- Pass & Seymour RT24
- Leviton VPT24-1P

2.5 Outdoor Photocell

- .1 Outdoor photocell for exterior lighting: 120 volt

Standard of Acceptance

- Wattstopper HPSA
- Leviton PCOUT-000, PCOUT-0SV
- Hubbell DHOP
- Lutron GRX-CESO

- .2 Dimmers for 0-10V LED drivers and fluorescent ballasts:

Standard of Acceptance

- Lutron Diva DVSTV
- Leviton DS710-10
- Cooper DF10P

- .3 Colour:

- .1 Normal power: white
- .2 Emergency power: red.

2.6 Receptacles

- .1 Listed to CSA C22.2 No. 42.
- .2 Standard duplex style.
- .3 Heavy duty industrial/specification grade.
- .4 With the following features:
 - .1 eight back wired entrances, four side wiring screws,
 - .2 suitable for no. 10 AWG for back and side wiring,
 - .3 break-off links for use as split receptacles,
 - .4 triple wipe contacts,
 - .5 riveted or integral ground contacts.
- .5 Colour coded as follows:
 - .1 Normal power: white,
 - .2 Emergency power: red.
- .6 One manufacturer throughout the project.

Standard of Acceptance

- Pass & Seymour (Legrand)
- Hubbell
- Bryant Electric
- Eaton Wiring Devices (Arrow Hart)
- Leviton

- .7 Weatherproof: complete with:
 - .1 15 ampere, 120 volt receptacle as listed below,
 - .2 weatherproof box,
 - .3 "While-In-Use" weather protective cover:
 - (a) polycarbonate material,
 - (b) clear lockable cover,
 - (c) deep cover,
 - (d) attached gasket,
 - (e) stainless steel hardware,
 - (f) marked "extra duty".

Standard of Acceptance

- Pass & Seymour No. WIUCED10DCL
- Hubbell Taymac No. MM410CCN

.8 Weatherproof: complete with:

- .1 15 ampere, 120 volt receptacle as listed below,
- .2 weatherproof box,
- .3 "While-In-Use" weather protective cover:
 - (a) cast material,
 - (b) lockable cover,
 - (c) deep cover,
 - (d) attached gasket,
 - (e) stainless steel hardware,
 - (f) marked "extra duty".

Standard of Acceptance

- Pass & Seymour No. WIUCAST1
- Hubbell Taymac No. MX3200C

.9 The receptacles listed below represent the most common configurations and are not necessarily used on this project. Refer to drawings for types used.

- .1 Duplex receptacle: 15 ampere, 120 volt, grounded CSA Configuration 5-15R:

Standard of Acceptance

Type	Catalogue Numbers				
	P & S	Hubbell	Bryant	Leviton	Eaton
Non-decora (Hospital grade)	5262 8200	5262 8200	5262 BRY8200	5262 8200	AH5262 8200
Decora (Hospital grade)	26252 26262HG	HBL2152 2172	9252 9200	16262 16262-HG	6262 8262

- .2 Isolated ground duplex receptacle: 15 ampere, 120 volt, CSA Configuration 5-15R:

Standard of Acceptance

Type	Catalogue Numbers				
	P & S	Hubbell	Bryant	Leviton	Eaton
Non-decora	IG5262	IG5262	BRY5262IG	5262-IG	IG5262
Decora	IG26262	-	-	-	-
(Hospital grade)	IG26262HG	-	9200IG	16262-IG	IG8262

- .3 Duplex receptacle: 15 / 20 ampere, 120 volt, grounded CSA Configuration 5-20R:

Standard of Acceptance

Type	Catalogue Numbers				
	P & S	Hubbell	Bryant	Leviton	Eaton
Non-decora (Hospital grade)	5362	5362	5362	5362	AH5362
	8300	8300	BRY8300	8300	AH8300
Decora (Hospital grade)	26352	HBL2162	9352	16362	6362
	26362HG	HBL2182	9300	16362-HG	8362

2.7 Cover Plates

- .1 Compatible with wiring device.
- .2 Stainless steel 18-8 chrome metal alloy, Type 302, vertically brushed, 1 mm (1/32") thick cover plates for wiring devices in flush-mounted outlet boxes.
- .3 Cast cover plates for wiring devices mounted in surface-mounted FS or FD type conduit boxes.
- .4 Engraving, where indicated:
 - .1 6 mm (¼") high letters filled with red paint,
 - .2 parallel to finished floor level.
- .5 One manufacturer throughout the project.

Standard of Acceptance

- Pass & Seymour (Legrand)
- Hubbell
- Bryant Electric
- Eaton
- Leviton

2.8 Ground Fault Circuit Interrupters (GFCI's)

- .1 CSA approved Type A.
- .2 Complete with suitable outlet box.
- .3 15A grounded duplex Decora receptacle type 5-15R.
- .4 15A/20A grounded duplex Decora receptacle type 5-20R where indicated.
- .5 Auto-monitoring (self-test), manual test feature and reset switch.
- .6 Units to include current transformer and sensing mechanism.
- .7 Unless noted otherwise, unit to trip at 6 mA.
- .8 No power at device face if reversed wired.
- .9 Colour coded as follows:
 - .1 Normal power: white,
 - .2 Emergency power: red.

- .10 Where shown in outdoor locations, units to be enclosed in "While-In-Use" weatherproof surface-mounted enclosures. In other locations units to be furnished with stainless steel cover plate.

Standard of Acceptance

Type	Catalogue Numbers				
	P & S	Hubbell	Bryant	Leviton	Eaton
15A:					
Decora	1597	GFR5262SG	GFRST15	7599	SGF15
(Hospital grade)	1597HG	GFR8200SG	GFST82	N7599-H	SGFH15
15/20A:					
Decora	2097	GFR5362SG	GFRST20	7899	SGF20
(Hospital grade)	2097HG	GFR8300SG	GFST83	N7899-H	SGFH20

3 EXECUTION

3.1 Identification

- .1 Label receptacles with circuit identification using a lamacoid label with colour coding for normal, emergency and UPS source with label attached to the receptacle or the wall above the receptacle.
- .2 Label receptacles in patient care areas in accordance with the latest version of CSA standard Z32:
 - .1 lamacoid label secured to the wall above the receptacle,
 - .2 engraved with the panel name and circuit number from which the receptacle is fed,
 - .3 lettering not less than 6 mm (¼") high,
 - .4 normal power: black lettering on white lamacoid,
 - .5 emergency power: red lettering on a white lamacoid.
- .3 Provide an additional lamacoid, of matching colour, for receptacles on dedicated circuits, stating: "Dedicated Circuit".
- .4 Identify receptacles, located within a patient care area but not intended for patient care use, with a nameplate stating "NOT FOR PATIENT CARE".
- .5 Label pilot light switches:
 - .1 lamacoid label secured to the wall above the switch,
 - .2 engraved with the name of the load controlled,
 - .3 black lettering on white background.

3.2 Installation

- .1 Switches;
 - .1 Mount switches vertically so that the switch contacts are closed when the toggle is up or, in the case of Decora switches, when the top part of the rocker is depressed.
 - .2 Install switches in gang type outlet box when more than one switch is required in one location.
 - .3 Provide separate boxes where switches are supplied from different power systems (normal and emergency).

- .4 Mount switches at heights specified in Section 26 05 01 - Electrical Basic Materials & Methods unless indicated otherwise.
- .5 Verify the door swing and ensure easy access before installing switches.
- .6 Switches installed adjacent to dimmers: provide switches that match appearance of dimmers.
- .7 Pilot light switches: run a neutral conductor to the switch.
- .2 Dimmers;
 - .1 Where more than one dimmer is shown in the same location, mount dimmers in individual backboxes.
 - .2 Where remote dimmers are utilized, install associated components in accordance with the manufacturer's recommendations.
- .3 Receptacles;
 - .1 Install receptacles in gang type outlet box when more than one receptacle is required in one location.
 - .2 Provide separate boxes where receptacles are supplied from different power systems (normal and emergency).
 - .3 Mount receptacles at heights specified in Section 26 05 01 - Electrical Basic Materials & Methods unless indicated otherwise.
 - .4 For each type of receptacle 20 ampere or larger, supply and hand to Owner two heavy duty caps.
 - .5 Connect receptacle grounding terminal to the outlet box with an insulated green bonding conductor.
 - .6 Verify exact position of service fittings to suit furniture layout.
 - .7 Do not mount receptacles directly on a column, unless column has been appropriately furred, to avoid breaking fire barrier.
 - .8 Where equipment is located on a rooftop, provide receptacle(s) for maintenance purposes:
 - (a) 15/20A weather resistant GFCI receptacle, type 5-20R,
 - (b) weatherproof while-in-use housing,
 - (c) located within 7.5 m of the equipment,
 - (d) mounted at least 750mm above the finished roof,
 - (e) supplied from a dedicated circuit,
 - (f) provide additional receptacles as required so that a receptacle is located within 7.5 m of each item of equipment.
- .4 Cover Plates;
 - .1 Protect stainless steel cover plate finish with paper or plastic film until painting and other work is finished.
 - .2 Install suitable common cover plates where wiring devices are grouped.
 - .3 Do not use cover plates meant for flush outlet boxes on surface-mounted boxes.
- .5 Ground fault circuit interrupters;
 - .1 Mount receptacles at height indicated in Section 26 05 01 - Electrical Basic Materials & Methods unless indicated otherwise.
 - .2 Do not connect GFCI receptacles to provide protection to downstream receptacles, unless specifically indicated.
- .6 Outlets in movable partitions;
 - .1 Co-ordinate installation of outlet boxes and conduits with the particular trade involved.

3.3 Testing

- .1 Verify the operation of illuminated handles in switches.
- .2 Verify the operation of lights on pilot light switches.
- .3 Test each receptacle for correct polarity and ground continuity.
- .4 Test the manual trip and reset functions of each GFCI.

END OF SECTION

WIRE AND BOX CONNECTORS 0-1000 V 26 27 28

1 GENERAL

1.1 Scope

- .1 Provide wire and box connectors for wiring 1000 V and less, as shown.

1.2 Applicable Codes and Standards

- .1 Product standards:
 - .1 CSA C22.2 No.65 Wire Connectors.
 - .2 CSA C22.2 No.188 Splicing Wire Connectors.

2 PRODUCTS

2.1 Materials

- .1 Mechanical pressure type wire connectors:
 - .1 for copper conductors: current carrying parts of copper or tin plated aluminum,
 - .2 for aluminum conductors: current carrying parts of aluminum.

Standard of Acceptance

- Burndy
- IlSCO
- Thomas & Betts

- .2 Compression type pressure wire connectors:
 - .1 long barrel
 - .2 tin plated copper for copper conductors
 - .3 aluminum for aluminum conductors

Standard of Acceptance

- Burndy
- IlSCO
- Thomas & Betts

- .3 Twist on wire connectors:
 - .1 for copper wire up to and including #6 AWG,
 - .2 "live" spring construction,
 - .3 corrosion resistant spring,
 - .4 square wire spring construction,
 - .5 polypropylene cap rated for 105°C

Standard of Acceptance

- T&B Murette
- Ideal
- 3M

- .6 For damp, wet, outdoor and submersible locations: filled with silicone gel.
- .4 Fixture type splicing connectors:
 - .1 current carrying parts of copper,
 - .2 sized to fit copper conductors 10 AWG or less,
 - .3 temperature rating of not less than 105°C

Standard of Acceptance

- Burndy
- Hubbell
- Thomas & Betts

3 EXECUTION

3.1 Installation

- .1 Provide connectors in accordance with the manufacturer's recommendation for the size, quantity and type of wires.
- .2 Install connectors in accordance with the manufacturer's recommendations.
- .3 Remove insulation carefully from ends of conductors:
 - .1 where the conductor is damaged, remove the damaged portion and strip the insulation back further as necessary,
 - .2 where the conductor is too short, replace the conductor.
- .4 For aluminum conductors, clean the conductors and immediately coat with electrical joint compound.
- .5 Tighten screws of mechanical pressure type connectors in accordance with the manufacturer's recommendations. Installation to meet secureness tests in accordance with CSA C22.2 No.65.
- .6 Install compression type connectors using the appropriate compression tool and die as recommended by the manufacturer. Make two crimps on each wire. Installation to meet secureness tests in accordance with CSA C22.2 No.65.
- .7 Remove all traces of electrical joint compound after each connection has been made.
- .8 Install fixture type connectors and tighten. Replace insulating cap.

END OF SECTION

ENCLOSED CIRCUIT BREAKERS

26 28 16.13

1 GENERAL

1.1 Scope

- .1 Low-voltage enclosed (moulded case) circuit breakers of 6000 A and less ("breakers"), for power distribution equipment, including:
 - .1 adjustable trip circuit breakers
 - .2 fused circuit breakers and high-fault protectors,
 - .3 instantaneous-trip circuit breakers,
 - .4 and accessories.
- .2 This Specification does not apply to moulded case switches that do not incorporate automatic overcurrent tripping devices.

1.2 Applicable Codes and Standards

- .1 Product standards:
 - .1 CAN/CSA C22.2 No. 5.1 Moulded Case Circuit Breakers

1.3 Submittals

- .1 Submit shop drawings and product data for products specified herein.
 - .1 Include time-current characteristic curves for breakers with ampacity of 200 A and over or with interrupting capacity of 22,000 A symmetrical (rms) and over at system voltage.

2 PRODUCTS

2.1 General Requirements for Breakers

- .1 Bolt-on moulded case circuit breaker: quick- make, quick-break type, for manual and automatic operation, for operation at 600 V or less, and a current rating not exceeding 6000 A.
- .2 Common-trip breakers: with single handle for multi-pole applications.
- .3 Magnetic instantaneous trip elements in circuit breakers to operate only when value of current reaches setting. Trip settings on breakers with adjustable trips to range from 5 - 10 times current rating.
- .4 Circuit breakers over 150A ratings to have interchangeable trips.
- .5 50,000 Amps symmetrical interrupting rating at 600 volts

2.2 Thermal Magnetic Breakers

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

2.3 Solid State Trip Breakers

- .1 Enclosed moulded case circuit breaker to operate automatically by means of;
 - .1 a solid-state trip unit with associated current monitors and self-powered shunt trip to provide inverse time current trip under overload condition, and

.2 long time, short time, instantaneous tripping for phase, ground fault and short circuit protection.

2.4 Features

- .1 Breakers to include:
 - .1 on-off locking device,
 - .2 handle mechanism.

2.5 Enclosure

- .1 Mount individually mounted breakers in CEMA 3 enclosure.

3 EXECUTION

3.1 Installation

- .1 Install circuit breakers as shown.

END OF SECTION

DISCONNECT SWITCHES UP TO 1000 V

26 28 16.16

1 GENERAL

1.1 Scope

- .1 Provide enclosed disconnect switches for wiring systems of 1000 V or less, as shown.

1.2 Related Sections

- .1 Without limiting the scope of work or applicability of other specification sections, the work under this section directly integrates with or refers to the following specification sections:
 - .1 26 28 13 Fuses

1.3 Applicable Codes and Standards

- .1 Product standards:
 - .1 CSA C22.2 No. 4 Enclosed and Dead Front Switches.
 - .2 CSA C22.2 No. 39 Fuseholder Assemblies.

1.4 Submittals

- .1 Submit shop drawings for each type and size of switch.

2 PRODUCTS

2.1 Disconnect Switches

- .1 Listed to CSA C22. 2 No. 4.
- .2 Electrical enclosure: fusible and non-fusible disconnect switch in CSA C22.2 No. 94.1 Type 1 sprinkler proof or Type 3R enclosure, sizes as indicated.
- .3 2 pole or 3 pole as required for single phase or three phase circuits.
- .4 2 pole with solid neutral for three wire circuits with neutral.
- .5 3 pole with solid neutral for four wire circuits with neutral.
- .6 6 pole for two speed motor applications.
- .7 HP rated where used in motor circuits, with rating not less than the largest motor in the circuit.
- .8 Provision for padlocking switch in OFF position.
- .9 Mechanically interlocked door to prevent opening when handle in ON position.
- .10 Fuses: size as indicated, and to conform to Specification section 26 28 13.
- .11 Fuse holders:
 - .1 listed to CSA C22. 2 No. 39.,
 - .2 suitable without adaptors, for type and size of fuse indicated.
- .12 Heavy Duty, quick-make, quick-break action, rated for load breaking operation.
- .13 ON-OFF switch position indication on switch enclosure cover.
- .14 Auxiliary NO/NC contact in switches used for hydraulic elevator motors.
- .15 Rust inhibiting process to enclosures prior to finishing.
- .16 Finish enclosures using manufacturer's standard process, colour to be grey ASA No.49 or 61.

2.2 Double Throw Switches

- .1 Listed to CSA C22. 2 No. 4.
- .2 Non-fusible manual load transfer switch in CSA C22.2 No. 94.1 Type 1 sprinkler proof or Type 3R enclosure, size as indicated.
- .3 Two pole, three pole or four pole as shown and as required.
- .4 Continuous duty.
- .5 HP rated where used to switch motor loads.
- .6 Visible blades for positive indication that switch is in the OFF position.
- .7 Provision for padlocking in the centre OFF switch position, and in both ON positions.
- .8 Heavy duty, quick make, quick break operating mechanism, rated for load breaking operation.
- .9 Mechanically interlocked door to prevent opening when handle in an ON position.
- .10 ON-OFF-ON switch position indication on switch enclosure cover.
- .11 Rust inhibiting process to enclosures prior to finishing.
- .12 Finish enclosures using manufacturer's standard process, colour to be grey ASA No.49 or 61.

Standard of Acceptance

- Square D/Schneider Electric
- Eaton (Cutler- Hammer)
- Siemens Canada Ltd.
- General Electric

3 EXECUTION

3.1 Installation

- .1 For sprinklerproof and CSA Type 3R enclosures use watertight connectors complete with O rings for conduit connections.
- .2 For switches used for hydraulic elevator motors run 3#12 in conduit from the auxiliary NO/NC contacts in the disconnect to the elevator control cabinet and terminate as per the elevator supplier's instructions.
- .3 Provide fuses in disconnect switches, sizes as shown.

END OF SECTION

POWER GENERATION DIESEL 26 32 13

1 GENERAL

1.1 General Requirements

- .1 Conform to Sections of Division 00 and Division 01 as applicable.

1.2 Applicable Codes and Standards

- .1 Latest edition of:
 - .1 CSA C22.1 Ontario Electrical Safety Code,
 - .2 CSA C282 Emergency Electrical Power Supply for Buildings,
 - .3 CSA Z32 Electrical Safety and Essential Electrical Systems in Health Care Facilities.

1.3 Related Sections

- .1 Without limiting the scope of work or applicability of other specification sections, the work under this section directly integrates with or refers to the following specification sections:
 - .1 26 01 01, Electrical General Requirements.
 - .2 26 05 01, Electrical Basic Materials and Methods.
 - .3 26 05 48, Vibration Isolation
 - .4 26 05 49, Seismic Restraints.
 - .5 26 32 43, Enclosures for Facility Power Generation Equipment

1.4 References

- .1 NETA, Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems.
- .2 The system shall meet the requirements of the latest editions of CSA C282 and CSA Z32 and additional requirements as noted herein. System shall comprise a fully automatic emergency generating plant capable of automatic starting and producing rated power in the event of failure of normal supply.
- .3 Where the requirements of this Specification exceed those of above-mentioned standards, this Specification to govern.

1.5 Work Included

- .1 Provide labour, materials, and equipment required for installation, testing, delivery and putting into proper operation complete systems as shown as specified and as otherwise required.
- .2 General Schedule of equipment to be provided:
 - .1 One (1) 450 kW, 563 kVA, 120/208 volt, 3 phase, 4 wire, prime power rated diesel generator for emergency power generation in a Class A health care facility. System shall meet CSA C282-19 and CSA Z32-21, be certified to meet the requirements of EPA Tier 2 levels for emissions, and be capable of automatic starting and producing rated power in 8 seconds or

- less to supply vital loads within 10 seconds of a utility power failure (allowing a 2 second delay for an ATS to sense loss of normal power and provide the start signal to the generator).
- .2 Outdoor weatherproof sound attenuated walk-in type enclosure for the diesel generator including sub-base mounted fuel tank of sufficient capacity for the unit to run at maximum site design load for 72 hours.
 - .3 Starting batteries and chargers.
 - .4 Control batteries and chargers.
 - .5 Generator mounted control panel complete with generator output circuit breaker, generator controls, monitoring, alarms, metering, generator fault and run signals and ATS position status indication.
 - .6 Control wiring connections and interface with:
 - two ATS in the facility.
 - Fire Alarm system
 - Network interface for connection to existing BAS system
- .3 The services to be provided by the supplier under this section shall include but shall not be limited to the following for a complete and satisfactory operating system.
- .1 Shop drawings, fabrication and assembly as per "reviewed" shop drawings.
 - .2 Interface control wiring diagrams, schedules and wire running lists between all components supplied and to automatic transfer switches and synchronization generator switchboard.
 - .3 Factory testing, and supplementary acceptance testing for witness by Engineer. Factory Acceptance Testing (FAT) procedure shall be submitted as a shop drawing for review by the Consultant .
 - .4 Delivery schedule and delivery F.O.B. Job site.
 - .5 Technical supervision of unloading, site assembly, installation of power and control cable connections, battery installation and connections, and all other work normal to the electrical trade.
 - .6 Commissioning, site testing including Site Acceptance Testing (SAT) and Integrated Systems Operational Tests (ISOT) with temporary load banks. SAT procedure shall be submitted as a shop drawing for review by the Consultant. Rental cost of full capacity load bank shall be included in Tender Price. Handling, installation, temporary wiring and removal shall be by the generator Supplier.
 - .7 Providing technical staff and manuals for factory and field training of Owner's staff in the complete operation of the system.
 - .8 Warranty service on a priority basis (within 4 hours).
 - .9 Data book including schematic diagrams of all circuit boards.
 - .10 Check out of system one month prior to expiry of warranty period.
 - .11 Unloading, hoisting and setting into place, and work normal to the electrical, mechanical and millwright trades such as providing interface power and control wiring to terminals within the equipment components and installation of major components shall be done by the Supplier.
- .4 Include for the services of qualified factory trained technicians and service representatives to be on site for commissioning of systems and components and during the on-site "witness" testing program as long as necessary to make final adjustment for acceptance of the system. Include a minimum of four (4) days for manufacturer's factory service technician for on-site commissioning and testing including all expenses. If additional days are required, Installation Contractor (named later) is responsible for compensating equipment Supplier for presence of manufacturer's factory service technician on-site.

- .5 Include for the services of qualified factory trained technicians and service representatives to conduct training of the facility operating staff in the operation and maintenance of the overall emergency power system. Include for a total of three separate full day training sessions. Should equipment fail during a training session, conduct a repeat session.
- .6 All on-site testing, and site work requiring shutdowns, shall be performed at the Hospital's convenience. Assume premium time, between the hours of 23:00 to 06:00, on weekends.

1.6 Warranty and Maintenance

- .1 The Supplier shall warrant all equipment furnished under this contract for a period of 2 years following final site acceptance against:
 - .1 Faulty or inadequate design, manufacture, improper assembly, or operation.
 - .2 Defective material or workmanship, or both.
 - .3 Leakage, breakage or other failure that might occur under normal and proper operation of the equipment.
- .2 The manufacturer shall correct any deficiencies in his equipment which occur during the 2 year warranty period at no additional cost to the Owner. This shall include all costs for material and labour. The manufacturers technical representative shall be available on site on a priority basis i.e., within 4 hours of being notified of a deficiency to repair the system.
- .3 Prior to the expiry of the warranty period, i.e. during the last month of the period, provide technical staff on a weekend to conduct an in depth checkout of the total emergency power system. Replace any components which have become degraded to the point where their long term performance is questionable. The cost of this service shall be included in the bid price.
- .4 Cost for service calls made necessary to maintain the total emergency power system in optimal operating conditions during the two year warranty period shall be included in the bid price.

1.7 Submittals with Bid

- .1 The following drawings and information are to be submitted with the bidder's tender:
 - .1 Location of nearest local office staffed with regularly employed engineers and/or technicians who have been factory trained in the installation and service of the proposed equipment.
 - .2 Name and location of factory trained engineers and technicians in regular employment with the system supplier qualified to service the proposed equipment.
 - .3 Typical response time for a qualified factory trained service engineer or technician to be on site following an "emergency" service call.
 - .4 A document of compliance indicating compliance with each article of the specification, where compliance is not possible the article shall be noted and an explanation given, the document of compliance shall be signed by an officer of the company supplying the system.
 - .5 Failure to provide the above information will result, at the discretion of the engineer, in the rejection of the tender.
- .2 Submit the following information in a binder, indicating make, model, type, dimensions, ratings, etc., to assist with the preliminary evaluation of bidder's technical conformance:
 - .1 Engine
 - .2 Alternator
 - .3 Governor

- .4 Voltage Regulator
 - .5 Paralleling switchgear
 - .6 Load Bank
 - .7 Tap Box for connecting a rental mobile generator
 - .8 Weights of all components
 - .9 Dimensioned outline of unit
 - .10 Brake horsepower versus rated speed curves
 - .11 Cooling ventilation data
 - .12 Cooling fan static pressure capability external to radiator
 - .13 Diesel fuel consumption
 - .14 Performance curves for local conditions and multipliers for ambient temperatures
 - .15 Confirmation of diesel exhaust back pressure, and exhaust pipe diameter.
 - .16 For the specific engine-alternator combination proposed, confirm:
 - (a) Start-up time: that the unit will start and reach stable voltage and frequency in 8 seconds or less upon receipt of the start signal (from the ATS).
 - (b) transient frequency and voltage performance, identifying the % deviation and recovery time back to steady-state under specified one-step load conditions, including
 - 0-100%, 0-66%, 0-33%, 33 - 66%, and 66-100% load steps.
 - .17 Noise data for genset and load bank
 - .18 Engine exhaust emissions data
 - .19 List of components
- .3 Preliminary physical construction drawings of genset, completely dimensioned, showing:
- .1 Arrangement.
 - .2 Plan, front view, and elevation views.

1.8 Shop Drawings and Product Data

- .1 Submit shop drawings and product data, to include:
- .1 list of components
 - .2 engine
 - .3 alternator
 - .4 voltage regulator
 - .5 governor
 - .6 battery charger
 - .7 battery
 - .8 Cooling fan static pressure capability external to radiator.
 - .9 cooling system
 - .10 engine and generator mounting, including vibration isolators
 - .11 silencer
 - .12 location of fuel and lube oil filters

- .13 Fuel-water separator
 - .14 lube oil and coolant drain valves
 - .15 air cleaners
 - .16 engine instrument panel
 - .17 genset control panel
 - .18 engine mounted control panel
 - .19 starting motor
 - .20 block heaters
 - .21 power and control junction boxes
 - .22 engine and generator mounting feet
 - .23 weights of all components
 - .24 Dimensioned outline of unit
 - .25 Confirmation of Diesel exhaust pipe diameter
 - .26 Brake horsepower versus rated speed curves
 - .27 Diesel fuel consumption and cooling water data
 - .28 Performance curves for local conditions and multipliers for ambient temperatures
 - .29 Generator decrement curves against generator main breaker curve
 - .30 Efficiency of generator
 - .31 Confirmation of diesel exhaust back pressure and water coolant requirements.
 - .32 flow diagrams for fuel, lubricating oil, and cooling systems
 - .33 engine and generator control wiring diagrams
 - .34 Noise data for genset and load bank
 - .35 Engine exhaust emissions data
- .2 Submit decrement and generator damage curves to show fault current sustaining ability of generator as outlined.
- .3 Submit description of set operation including
- .1 automatic starting and transfer to load and back to normal power, including time in seconds from start of cranking until unit reaches rated voltage and frequency.
 - .2 manual starting
 - .3 manual emergency stop
- .4 submit description of automatic shutdown and alarms on
- .1 over cranking
 - .2 over speed
 - .3 high engine temperature
 - .4 low lube oil pressure
 - .5 short circuit
 - .6 alternator over voltage
 - .7 lube oil high temperature
 - .8 thermistor over temperature on alternator

- .5 Physical Construction Drawings, completely dimensioned, showing:
 - .1 Arrangement.
 - .2 Plan, front view, and elevation views.
 - .3 Required clearances for opening doors and for removing breakers.
 - .4 Conduit or cable trays entrance locations and dimensions for top entrance.
 - .5 Bus bar locations and configurations.
 - .6 Incoming and outgoing power cable terminator positions.
 - .7 Field wiring terminal block locations, and all other terminal block locations.
 - .8 Anchor bolt locations.
 - .9 Grounding connections.
 - .10 Weight of equipment.
- .6 Three line diagrams, with ANSI device function numbers used throughout, shall show all:
 - .1 Instrument transformers.
 - .2 Relays.
 - .3 Meters and meter switches.
 - .4 Other pertinent devices.
- .7 Elementary Diagrams
 - .1 Elementary (schematic) wiring.
 - .2 Each elementary diagram shall show device and terminal block terminal numbers.
- .8 Control Switches
 - .1 Provide control switch development tables.
- .9 Detailed Connection (Wiring) Diagrams showing:
 - .1 Approximate physical location of all items in each unit.
 - .2 All wiring within each unit.
 - .3 All interconnecting wiring between units.
 - .4 Identification of all terminals, terminal blocks, and wires.
 - .5 Clear identification, by some distinguishing method, of all interface wiring to remote devices. This shall include, but not be limited to, leads from external current transformers, trip circuits from remote devices, auxiliary contacts to remote devices, AC control power, and separate incoming AC power. This shall also include spare auxiliary contacts and relay contacts which shall be wired to terminal blocks for future use.
- .10 Factory Acceptance Test (FAT) procedure

1.9 Operation and Maintenance Data

- .1 Provide operation and maintenance data for diesel generator for incorporation into Operation and Maintenance Manual.
- .2 Include in Operation and Maintenance Manual instructions for particular unit supplied and not general description of units manufactured by supplier. Include all nameplate/sizing information.

- .3 Five (5) complete sets of operation and maintenance manuals shall be provided for the system. Turn over one set to the engineer. These manuals shall be applicable to the engine, generator, battery and charger, control panel including the circuit breakers, controls instrumentation and all other components of the assembly. The manuals shall include circuit and wiring diagrams, safety precautions, operating and maintenance instructions, including drawings, illustrations and identification of wiring.
- .4 Operation and maintenance instructions for engine and accessories, alternator and accessories, control panel, battery charger, battery, fuel system, engine room ventilation system, exhaust system and accessories, to permit effective operation, maintenance and repair.
- .5 Illustrated parts lists with parts catalogue numbers.
- .6 As Built schematic diagrams of electrical power, control, and logic circuits.
- .7 Flow diagrams for:
 - .1 Fuel system.
 - .2 Lubricating oil.
 - .3 Cooling system.
 - .4 Certified copy of factory test results.
 - .5 Maintenance and overhaul instructions and schedules.
 - .6 Precise details for adjustment and setting of time delay relays or sensing controls which require on site adjustment.

1.10 Maintenance Materials

- .1 Provide maintenance materials. Include:
 - .1 4 sets of fuel filter replacement elements.
 - .2 4 sets of lube oil filter replacement elements.
 - .3 4 sets of air cleaner filter elements.
 - .4 4 sets of fuses for engine mounted control panel.
 - .5 Special tools for unit servicing.
- .2 Provide one complete set of all special tools required for unit servicing.
- .3 Provide one battery service safety kit including:
 - .1 Full face shield
 - .2 Acid resistant gloves
 - .3 Acid resistant apron
 - .4 Acid neutralizing compound
 - .5 Eye wash bottle
 - .6 Battery top up bottle
 - .7 Acid resistant wall mount rack to support the above
 - .8 Hydrometer with wall mount bracket and acid resistant drip cup
 - .9 10 Litres of distilled water

- .4 Provide a heavy duty free standing spares storage cabinet of painted steel construction, approximately 1000mm wide by 450mm deep, with not less than six heavy duty adjustable shelves each capable of supporting 175 kg. and with two hinged lockable doors. Cabinet to house the maintenance materials, special tools, Operation and Maintenance Manual plus a log book. Locate free-standing cabinet in maintenance shop.

1.11 Source Quality Control

- .1 Manufacturer's Production Test and Records:
 - .1 Submit certified copies of reports of manufacturer's production testing.
- .2 Factory test generator set including engine, alternator, control panels, and accessories.
- .3 Prepare blank forms and check sheet with spaces to record data. At top of first sheet record:
 - .1 Date
 - .2 Generator set serial no.
 - .3 Engine, make, model, serial no.
 - .4 Alternator, make, model, serial no.
 - .5 Voltage regulator, make and model.
 - .6 Rating of generator set, kW, kVA, V, A, r/min, Hz.
- .4 Mark check sheet and record data on forms in duplicate as test proceeds.
- .5 Demonstration of automatic start system.
- .6 With 100% site rated full load, operate set for 4 h, taking readings at 30 min intervals, and record following:
 - .1 Time of reading.
 - .2 Running time.
 - .3 Ambient temp in °C.
 - .4 Fuel consumption
 - .5 Lube oil pressure in kPa.
 - .6 Lube oil temp in °C.
 - .7 Engine coolant temp in °C.
 - .8 Exhaust stack temp in °C.
 - .9 Alternator voltage:
 - .10 Alternator current:
 - .11 Power in kW.
 - .12 Frequency in Hz.
 - .13 Power Factor.
 - .14 Battery charger current in A.
 - .15 Battery charger current in A.
 - .16 Alternator cooling air outlet temp.

- .7 After completion of 4 h run, demonstrate following features, shut down devices and alarms: Demonstrate low oil pressure and high engine temperature shutdown devices operation without subjecting engine to these excesses.
 - .1 Cycle crank test
 - .2 Over cranking.
 - .3 Over speed.
 - .4 High engine temp.
 - .5 Low lube oil pressure.
 - .6 Alternator over voltage.
 - .7 Low battery voltage, or no battery charge.
 - .8 High alternator temperature.
 - .9 All other safety features
- .8 Next install continuous strip chart recorders to record frequency and voltage variations during load switching procedures. Each load change delayed until steady state conditions exist. Switching increments to include:
 - .1 No load to full load to no load.
 - .2 No load to 80% load to no load.
 - .3 No load to 50% load to no load.
 - .4 No load to 25% load to no load.
 - .5 25% load to 100% load to 25%.
 - .6 40% load to 90% load to 40%.
 - .7 50% load to 100% load to 50%.
- .9 Demonstrate
 - .1 Automatic starting of set and automatic transfer of load on failure of normal power.
 - .2 Operation of manual control switch.
 - .3 That battery charger reverts to high rate charge after cranking.

1.12 Training program

- .1 Include in the equipment supply tender price the services of a qualified technical representative at the site to conduct "hands-on" training programs for the Owner's staff.
- .2 The amount of time to be included in the tender is three (3) days at the site for a total of 24 hours, plus travel time.
- .3 The training shall include identification of components and diagnostic alarms as well as basic inspection, housekeeping and logging procedures.
- .4 Submit an outline of the training program for review, adjustment and approval by the engineer. Training will occur in 3 separate 1 day sessions, at a time convenient to the Owner, over the construction and warranty period.
- .5 Sessions may be video recorded by the Owner as an aid to ongoing training of Owners staff.

1.13 Preparation for Shipment

- .1 Preparation for Shipment shall be in accordance with manufacturer's standards, unless otherwise noted.
- .2 The manufacturer shall be solely responsible for the adequacy of the Preparation for Shipment provision employed in respect of materials and application, to provide materials and their destination in ex-works condition when handled by commercial carrier systems.

1.14 Shipping

- .1 The engine generator set assembly to be capable of withstanding normal shipping and handling shocks and vibration without damage or deterioration.
- .2 If shipped separately, any components to be individually crated and tagged with its proper unit number and the equipment number of the assembly to which it belongs.
- .3 Each "shipping section" to be provided with a permanently-attached, readily-visible identification tag bearing the equipment number of the assembly of which it is a part.
- .4 Cost associated with transportation, insurance and road permits for delivery of equipment to job site shall be included in the bid price.

1.15 Provisions for Handling and Field Erection

- .1 Each shipping split of stationary structures shall be furnished with removable lifting angles and/or plates suitable for crane hooks or slings.
- .2 Each shipping split shall also be furnished with removable steel channel base plates which will permit using pipe rollers or dollies without damaging the frame steel of the equipment.
- .3 Coordinate mounting requirements with the requirements of the Structural Engineer.

1.16 Installation

- .1 Installation of the diesel generator equipment to be in full accordance with, and under the technical supervision of the supplier. Provide drawings showing general arrangement of all components including batteries, interconnecting wiring drawings and schedules suitable for use by the successful contractor.
 - .2 Equipment to be arranged or crated with features which make it easy for hoisting, rolling and jacking into place without damage to the equipment.
 - .3 Include in the bid, the cost of a factory engineer or technician to supervise the site assembly and to commission, test, and certify the installation on site at a later date, TBA.
- .1

1.17 Temporary and Trial Usage

- .1 Temporary and trial usage by Owner of equipment or any other work or materials supplied before final completion and written acceptance shall not be construed as evidence of acceptance by Engineer.

- .2 Engineer to have the privilege of such temporary and trial usage, as soon as supplier shall claim that said work is completed and in accordance with specifications, for such reasonable length of time as is deemed to be sufficient for making a complete and thorough test of same.
- .3 Claims for damage shall not be made by supplier for the injury to or breaking of any parts of such work which may be used, whether caused by weakness or inaccuracy of structural parts or by defective materials or workmanship of any kind whatsoever.

1.18 Final Acceptance

- .1 Request for acceptance to be submitted in writing. Written request to not be submitted until:
 - .1 Deficiencies noted during job inspections have been completed.
 - .2 Systems have been pre-commissioned and tested and are ready for on-line operation.
 - .3 Completed data books have been submitted and approved.
 - .4 Diagrams have been submitted and approved, and equipment identification is completed.
 - .5 The cleaning up is finished in every respect.
 - .6 Spare parts and replacement parts specified have been provided and receipt of same acknowledged.
 - .7 Record drawings are completed and approved.
 - .8 Owner's operating personnel have been instructed in operation of systems.
 - .9 Operating manual has been submitted to Owner. Operating manual shall include fully detailed software program, documentation including descriptive sequence of operations and referenced to accompanying ladder logic diagrams. This material shall be used in training Owner's staff in the system operation, maintenance and diagnostics. Include the cost of the services of a technical representative for instructing the commissioning team in the system operation.

1.19 Operation of Emergency Power System

- .1 If any one or all phases of normal supply to the automatic transfer switch should fail, a contact in the transfer switch shall close and initiate automatic starting of the Diesel-generator unit.
- .2 Certain lighting loads, motors and pumps, supplied through transfer switches, to be automatically reconnected to emergency power supply by operation of the automatic transfer switch after the generator reaches rated voltage and speed, so that these items will continue to operate as required.
- .3 Automatic transfer switch will transfer its load back to normal source when normal power service is restored, and elevators will restart and return to normal operation.
- .4 Diesel generator shall continue to operate until shut down automatically after an adjustable cool down period, set at 10 minutes (adjustable from 0-60 minutes).
- .5 An auxiliary contact in automatic transfer switches elevator emergency power systems shall close upon connection to emergency source of power, and shall send a signal to elevator electronic controller.

2 PRODUCTS

2.1 General

- .1 The equipment comprising the system to be of proven design and standard manufacture except where protective devices alarm and annunciation features, instrumentation, performance requirements and services are identified in detail.
- .2 The equipment provided to be designed for unattended operation. The equipment shall include dry contacts for remote alarms suitable for use by the building management system.
- .3 Materials and parts comprising the system to be new, of current manufacture, of a high grade and free from all defects and imperfections and shall not have been in prior service, except as required during factory testing.
- .4 Active electronic devices to be solid state. Semiconductor devices to be hermetically sealed. Vacuum tubes to not be used for any purposes. Relays to be dust tight.

2.2 Nominal Size and Rating

- .1 Unit shall have a minimum **prime** power rating of 450 kW, 563 kVA at 80% power factor at 40°C ambient and other local conditions for continuous operation as defined in latest CAN/CSA Standards C282-19 and Z32-21 for Hospitals.
- .2 Unit shall have a minimum field applied nameplate that the unit is sized for 300kW of Maximum Site Design Load, as defined in CSA C282. (For clarity, the required prime power rating of 450kW is in excess of the Maximum Site Design Load).
- .3 The unit shall accommodate motor starting, 100% step loads without stalling, fault current duties and exhaust stack back pressure limitations all within the CSA specified tolerances and the tolerances specified herein.
- .4 The unit to be sized and set to provide 100% load in a 40°C ambient without exceeding CSA specified temperature, voltage and frequency limits and the limits specified herein.
- .5 The engine provided shall have additional BHP capacity for power requirements to drive engine driven components and accessories such as: radiator fan, fuel pump, water pump, as well as additional BHP allowances for motor starting duties, step loading changes, stack back pressure levels at 40°C ambient, all within CSA specified tolerances for voltage, frequency and temperature, and the tolerances specified herein.
- .6 Provide a lamacoid on the unit identifying: "Demand load not to exceed 300kW", per CSA C282.
- .7 The engine manufacturer's catalogued BHP curves for Standby Rating to be based on continuous duty conforming to or exceeding the following standards:
 - .1 SAE J816b (US)
 - .2 BS5514 (British)
 - .3 DIN "B" 6270 (European)
 - .4 ISO 3046/1

2.3 Performance Characteristics

- .1 The equipment shall be suitable for operation and providing full output power as per the manufacturers guaranteed performance profile under the following conditions:
 - .1 Altitude 160 meters above sea level
 - .2 Outside ambient -30°C to 32°C nominal
 - .3 Room ambient 10°C to 40°C nominal
- .2 Start up time
 - .1 The diesel generator unit shall start and reach stable voltage and frequency in 8 seconds or less upon receipt of the start signal
- .3 Frequency Control - Governor control on each unit to maintain output frequency within the following limits:
 - .1 Frequency drift - with any constant load between no load and rated load, the change in regulated frequency to be plus or minus 0.25 Percent from rated.
 - .2 Steady-state - frequency control to be within plus or minus 0.25 Percent from rated when the load is varied from no load to rated load and all transients have decayed.
 - .3 Frequency variations during steady-state conditions shall show a random nature (as opposed to cyclic variations).
- .4 Voltage Regulation - voltage control of generator output to be within the following limits:
 - .1 Voltage drift - with any constant load between no load and rated kVA, the change in regulated output voltage shall not exceed plus or minus 0.5 percent within one-half hour and a constant ambient temperature.
 - .2 Steady-state voltage regulation - voltage regulation to be plus or minus one percent of rated voltage when the load is varied from no load to rated kVA and all transients have decayed.
- .5 Addition of a 100% step load shall not cause the engine to stall. Removal of a 100% step load shall not cause the engine to shut down.
- .6 Transient voltage and frequency deviation and recovery time upon addition and deletion of a 75% load in one step shall not exceed
 - .1 10% frequency deviation
 - .2 3 seconds to return to steady state

2.4 Diesel Engine

- .1 Engine to be a four stroke, single acting, full compression ignition type with a maximum crankshaft speed of 1800 rpm.
- .2 Engine to be a low emissions type certified to meet the requirements of the U.S. Environmental Protection Agency Tier 2 limits for a stationary emergency application.
- .3 Engine to operate on commercial grades of diesel fuel oil readily available locally and shall give satisfactory performance on No. 2 Grade domestic fuel oil in an emergency.

- .4 Engine to incorporate dry vortex type air cleaners equipped with service indicators, of replaceable element type, with an efficiency of at least 99.8%. Service indicators are not to be mounted in rubber hose.
- .5 Diesel engine to be suitable for a stack back pressure of 8.0 kPa.
- .6 Flex connection at engine exhaust complete with gaskets, nuts, bolts and miscellaneous hardware.
- .7 All moving parts such as flywheels, pulleys, belts, etc., to be enclosed with suitable guards to protect the engine operator from accidental injury. All guards to be easily removable for servicing the equipment.
- .8 Engine to be complete with inter-changeable cylinder heads, exhaust valves constructed of special alloy steel, and satellite faced exhaust valve inserts.
- .9 Provide with the engine a flexible 100mm diameter hose of proper diameter and sufficient length to reach from the engine crankcase vent connection to the atmosphere side of the radiator exhaust plenum, for venting of crankcase fumes to atmosphere.
- .10 Engine to be equipped with dual 24 volt D.C. electric starting motors, and the starting pinion to be arranged to disengage automatically when the engine starts.
- .11 Engine to also be equipped with individual safety devices to shut-down the engine and to sound an alarm in the event of conditions specified later in this Section, and equipped with contacts to pre-alarm for conditions specified later in this Section.
- .12 Each engine flywheel housing to be connected rigidly to the generator housing with an SAE adaptor. The unit to be mounted on a heavy duty, stress relieved, fabricated steel baseplate. Torsional approval of each entire assembly must be obtained and submitted in duplicate to the Consultant for review. Each report to also outline the critical speeds of the assembly.
- .13 Removable guards to be provided around all moving parts and high temperature areas to protect operating personnel.

2.5 Governor

- .1 Governor to be manufacturer's current OEM electronic high performance standard system for load sharing and speed control of the units. Governor package to be complete with magnetic pickup.
- .2 The governor control system to include filtering of harmonics to provide true RMS electrical inputs to the speed control system.
- .3 Governor to be capable of isochronous operation, no load to full load and capable, under any steady state condition, of maintaining engine speed within $\pm 0.25\%$.
- .4 The governor shall operate in an isochronous mode.
- .5 Input voltage and current signals to be fed into the governor from current and potential transformers supplied with the governor as part of this Contract.
- .6 The governor to be capable of the following performance:
 - .1 Operating the engine isochronously under steady state conditions from no load to full load.
 - .2 Transient regulation response as specified.

- .3 Frequency drift as specified.
- .4 Steady state speed regulation as specified.
- .5 The governor control system to include filtering of harmonics to provide true RMS electrical inputs to the speed control system.

2.6 Engine Cooling System

- .1 Engine cooling system to include built-in centrifugal type water circulating pump and thermostat to maintain proper jacket water temperature under each load condition.
- .2 Cooling system components and seals with flexible braided steel water hose connections.
- .3 Engine to be cooled by an integral radiator and blower fan cooling system including permanent anti-freeze to -40°C as recommended by engine manufacturer.
- .4 Radiator to have sufficient capacity for cooling the engine under full load conditions in an ambient temperature up to 40°C. Include for sizing to accommodate static pressure loss through louvers, silencers and dampers. Manufacturer to verify this pressure drop and oversize as required to deliver full rated load under 40°C ambient temperature. At a minimum, unit to be designed for 0.75" external static pressure drop. Manufacturer to supply flexible duct adapter.
- .5 Radiator to be equipped with a coolant liquid level indicator with alarm contacts.
- .6 Fan to be pusher type, with ample means for adjustment to allow for belt stretching and to be enclosed in an easily removable cage.
- .7 Engine to be complete with thermostatically controlled engine coolant pre-heater, Kim Hotstart to maintain coolant around combustion chamber of approximately 10°C. Preheater water circuit to be equipped with position indicating ball type shut off valves to permit removal of heater without draining of coolant from the system. Include heavy duty thermostat equal to United Electric Model #120 complete with heavy duty engine mounted relay to shut off heater when engine is running.
- .8 Ball drain valves shall be provided for draining coolant from each engine block, radiator and jacket heater.

2.7 Engine Monitoring Panel

- .1 The following gauges to be supplied and to be flexibly mounted on engine:
 - .1 Coolant in and out temperature gauges
 - .2 Engine water temperature gauge
 - .3 Lube oil pressure gauge
 - .4 Lube oil temperature
 - .5 Tachometer
 - .6 Run Hour meter
 - .7 Exhaust temperature thermometer
 - .8 Fuel Oil Water separator vacuum
- .2 Panel to be equipped with an integral shrouded emergency stop pushbutton.

2.8 Lube Oil System

- .1 Engine to be provided with full pressure lubrication with high capacity positive displacement type gear driven pumps, with adjustable pressure regulators, replaceable element filter with bypass valve, supplying filtered lubricating oil under pressure to main bearings, crank pin bearings, piston pins, timing gears, camshaft bearings, valve rocker mechanism, governor and turbocharger. Full pressure lubrication to be provided to all main bearings, connecting rod bearings and camshaft bearings.
- .2 Readily accessible ball valves with suitable piping shall be provided for convenient draining of complete lubricating oil system.
- .3 An air-cooled lubricating oil cooler to be included.
- .4 Engine shall be complete with thermostatically controlled oil sump heater, rated 120 volts, single phase, complete with heavy duty engine mounted relay to shut off heater when engine is running.

2.9 Fuel System

- .1 Engine fuel system designed to allow for a return fuel back pressure of not less than:
 - .1 a static pressure lift to the return fuel cooler of not less than 3.0 m (10 ft), measured from the engine return-fuel oil connection,
 - .2 a dynamic pressure loss of 35 kPa (5 psi) for piping losses at the maximum return oil-flow rate, and
 - .3 the dynamic pressure loss of the remote fuel cooler at the maximum return oil-flow rate.
- .2 Engine mounted high performance fuel transfer pump with filter assembly.
- .3 Fuel filter shall have replaceable elements that can be easily removed without disturbing other parts of engine. Equip engine with primary and secondary fuel filters.
- .4 Equip engine with a Fuel Filter/Water Separator. Include a control panel mounted #18-1551 vacuum pressure gauge connected between engine and filter.
- .5 Provide fuel priming pump equal to Gorman Rupp complete with manual valve for bypass arrangement. The valves shall have a stainless-steel body with teflon seats and self-locking handle.
- .6 Provide braided stainless steel aircraft quality flexible fuel oil connections, Aeroquip or approved equal, rated for 1000F in supply and return, from engine to filters, between filter components, and from filters to valved connections left by Division 20. Flexible fuel lines shall be supplied by Diesel manufacturer.

2.10 Fuel Cooler

- .1 Stand-alone return-fuel cooler for remote installation.
 - .1 integral return fuel piping mounted on the engine radiator does not meet this requirement.
- .2 Performance:
 - .1 fuel cooler sized to cool return fuel oil to the auxiliary tank based on the following parameters:

(a) fuel oil flow rate (to fuel cooler):	as determined by generator manufacturer
(b) supply fuel oil (to engine) temperature:	30°C (86°F)
(c) return fuel oil (to fuel cooler) temperature:	as determined by generator manufacturer
(d) fuel cooler outlet fuel temperature:	not exceeding 38°C (100°F)

- (e) entering air temperature to fuel cooler: 32°C (90°F)
- .2 fuel dynamic pressure loss at maximum return fuel flow: as determined by generator manufacturer.
- .3 Construction:
 - .1 fuel-to-air heat exchanger, aluminum fin on copper tube, or steel fin or steel tube heat exchanger, with propeller fan and 208 VAC, single or three phase, induction or EC motor,
 - .2 provided with combination unfused disconnect and magnetic starter with hand-off-auto switch, with interlock to start cooler when diesel engine is operating, with overload protection and a current monitoring transmitter to allow remote monitoring by the Building Management System.
 - .3 design pressure rating: 420 kPa (60 psi),
 - .4 design temperature rating: 121°C (250°F)

2.11 Generator

- .1 Three phase brushless, self-ventilating, revolving field synchronous machine of salient pole construction with amortisseur windings with permanent magnet pilot exciter, IP23 drip-proof construction, single bearing type connected to the engine through a flexible coupling with shear bolts.
- .2 Diesel-driven alternator to be complete with necessary controls and accessories, to comprise a fully automatic standby generating plant capable of producing power in event of failure of normal supply. Generator to be capable of operating on system voltage shown, 80% power factor and maximum 1800 rpm.
- .3 Generator shall include fully connected damper windings and stator windings shall be 2/3 or 5/6 pitch to provide low reactance at the 5th and 7th harmonics for three phase non-linear loads. Total harmonic distortion shall not exceed 4% on a 3 phase balanced harmonic free load. Telephone interference factor for harmonic content shall not exceed 50.
- .4 Generator insulation shall be Class H. When operating continuously at full load the average winding temperature measured by rise of resistance method shall not exceed 130°C at an ambient of 40°C.
- .5 Generator shall be of rotating field type with permanent magnet pilot exciter and shall be capable of maintaining at an ambient of 40°C the following: 100% of full load continuously; 150% of full load for 1 minute; and 300% of full load for 10 seconds, at terminals of generator, without damage to generator, for the following fault conditions:
 - .1 3 phase symmetrical fault,
 - .2 phase to phase fault,
 - .3 phase to ground fault.
- .6 Generator to be complete with automatic voltage regulator, Stamford Series MX321 or equal (3 phase RMS voltage sensing) acting on each phase and capable of controlling voltage within $\pm 1/2\%$ of rated voltage, no load to full load, during steady state conditions.
- .7 Set to be sized to accommodate 100% block loading.
- .8 Set to be oversized as required, to limit the equivalent per unit sub-transient reactance to below 0.07 pu on a 300 kW rating, based on the submitted alternator's 125C kW / x"d rating.
- .9 Generator voltage to be 120/208 volts, 3 phase, 4 wire.
- .10 Identify alternator windings with permanent tags.

- .11 Bring windings to insulated terminals in an oversized metal junction box mounted on the alternator. Size junction box to permit mounting of engine and alternator low voltage controls and wiring terminal blocks, and to provide adequate space for terminating outgoing power cables with 2 hole long barrel compression connectors exiting from the bottom with adequate allowance for cable bending radius. Provide barrier in junction box to separate control voltage and line voltage wiring.
- .12 Provide gasketted removable aluminum termination plate suitable for entry of single conductor cables.
- .13 Provide a tinned copper termination plate drilled to accept multiple 2-hole compression connector terminated cables per phase, and necessary bus bar extensions to generator winding terminals.
- .14 Thermistors to be embedded in stator winding and connected to alternator control circuitry.

Standard of Acceptance

- Caterpillar
- Stamford HC Series
- Marathon MagnaMAX DVR series

2.12 Generator Excitation System

- .1 Exciter to be a brushless type using a rotating 3 phase full wave rectifier bridge circuit and a 3 phase rotating armature type alternating current generator mounted on the rotor shaft rated to provide excitation current necessary to operate alternator at rated output continuously for all overload conditions and to maintain specified voltage regulation under transient conditions.
- .2 Voltage regulator system to have frequency dependent circuitry with adjustable voltage roll-off feature to aid engine speed recovery for step loads. Include for fine tuning at the engine supplier's plant and at the site for optimization of the settings.
- .3 Voltage regulator to be solid state silicon controlled rectifiers with phase controlled sensing circuit, regulation $\pm\frac{1}{2}\%$ no load to full load. Provide auto/manual control module, and individual hand trimmer adjustment located at control cubicle.
- .4 The voltage regulator circuitry shall include:
 - .1 Control to adjust the stabilizing or anti-hunt circuit which controls overshoot or undershoot of the alternator voltage or load changes.
 - .2 Current forcing circuit to supply a minimum of 300% of nominal alternator output for at least 10 seconds to allow proper co-ordination of system protective devices.
 - .3 Manual control for adjustment of the automatically regulated generator voltage by $\pm 5\%$.
- .5 Excitation system for each unit to be complete with permanent magnet generator (PMG) pilot excitation system with a 3 phase RMS voltage sensing unit to provide $\pm 0.5\%$ voltage regulation. The AVR shall be immune to RIF and shall include built-in solid state overvoltage protection and adjustable short circuit current forcing controls and a separate trimmer unit mounted on the switchboard.
- .6 The voltage regulator to have the following performance features:
 - .1 Regulating the output voltage of the generator when it is disconnected from the load, supplying load alone, supplying load in parallel with the other sets.
 - .2 Steady state voltage regulation as specified.
 - .3 Voltage drift as specified.

.4 Transient voltage regulation as specified hereinbefore.

- .7 Mount the generator voltage regulator system in the generator control panel and provide suitable terminal blocks at each end to permit field interconnection to the generator terminal box with 8 #12 in 3/4" steel conduit. Components to be protected against dust and moisture.

2.13 Generator Grounding System

- .1 Generator to be solidly grounded with a #1/O copper stranded ground cable to ground bus bar. Do not bond the generator neutral to the generator case. Only ground the generator neutral conductor at the automatic transfer switch.

2.14 Safety and Alarm Devices

- .1 One set of temperature and pressure switches to be included for coolant system and lube oil system to provide instant shut-down action. Settings of these switches to be as recommended by Engine manufacturer. Over speed shall cause instant shut-down.

2.15 Starting System

- .1 Each engine to be supplied with a complete and independent starting system.
- .2 Electric starting system, minimum 24 volts, shall include dual starting motors, dual battery chargers, cutout, regulator and two sets of lead acid batteries.
- .3 Batteries to be capable of providing six consecutive 30 second cranking attempts without recharging, with terminal voltage not to fall below 75% of nominal voltage. Provide cranking limiter for one or more cranking cycles

Standard of Acceptance

- ° Surette 8NS-23P
- ° Or approved equal

- .4 Provide a steel battery rack with a 3/4" plywood base both painted with acid resistant paint.
- .5 Provide a hydrometer with wall mounting bracket.
- .6 Batteries shall come complete with extra flexible #4/0 AWG EPR insulated battery cables and compression connectors with battery rack with 3/4" painter plywood base.
- .7 Fully automatic dual rate battery charger capable of recharging batteries in 30 minutes following one normal start to be complete with battery rack, jumpers, cables and hydrometer.
- .8 When battery voltage falls below a level suitable for starting, a contact on a secondary relay shall close to cause an alarm signal to be sounded at the Control Panel.
- .9 Battery charger shall be a dual rate silicon rectifier battery charger for automatic float charge operating from 120 volts, single phase, 60 Hz having the following accessories and capacities:
- .1 Wall mounted sprinkler proof enclosure
 - .2 Silicon controlled rectifier assembly with DC protection, suitable for dual charging rates
 - .3 AC power on indication
 - .4 AC power failure indication
 - .5 Float voltage adjustment

- .6 Equalize circuit and timer
- .7 Overload protected input switch
- .8 DC output breaker complete with normally closed auxiliary contacts
- .9 DC ammeter, 3" semi-flush, 250E scale taut band suspension
- .10 DC voltmeter, 3" semi-flush, 250E scale taut band suspension
- .11 Short circuit current limit
- .12 Low voltage alarm with 60 second time delay (relay contacts which open for alarm, close normally wired out to terminal strip with appropriate connection) for supervisory control.
- .13 DC output breaker trip alarm (wire out auxiliary contacts on DC output breaker as for low voltage alarm).
- .14 Minimum charge rate to be 30 amps for battery charging and maximum charging time for fully discharged battery to 90% full charge shall not exceed six (6) hours.
- .15 Enclosure to be finished and painted to match generator set enclosure; interior to be white.

Standard of Acceptance

- Mechron
- Vulcan

2.16 Mounting Base

- .1 Diesel-generator package to be mounted on a structural steel base with suitable adjustable steel, restrained spring vibration isolators with 50 mm static deflection levelling bolts, oil proof snubbers, and 6mm thick sound pads mounted between steel base and floor. Isolation efficiency to not be less than 95%.

Standard of Acceptance

- Mason Model SLR
- Vibro-Acoustics
- Korfund

- .2 Vibration isolators to be anchored to the concrete floor with 5/8" anchors equal to Simpson Strong Tie Wedge All anchors with a minimum of 2 - 3/4' concrete cover.
- .3 The alternator set to be complete with hooks and hubs for the attachment of slings suitable for moving the unit.
- .4 Baseplates to be of sufficient rigidity to maintain alignment of engine generator shafts and frames under all conditions during shipping, installation and service and to be of all welded construction without bolt-on components.
- .5 Engine generator feet and baseplate sole plates to be machined parallel and true. Shimming to be of the steel type and shall only be permitted underneath the generator feet.
- .6 Provide all necessary piping, couplings, fittings, wiring and connections between all components mounted commonly on the steel base.
- .7 Provide full size galvanized steel drip pan under engine and a separate pan under the fuel filter assembly. Drip pan shall be 16 guage galvanized sheet steel, and designed to be easily removed from under engine.

2.17 Engine Alternator Finish

- .1 Finish and paint the complete engine generator assembly, base, and all accessories with one coat of primer followed by two coats of high temperature machinery enamel equal to the manufacturer's standard colour.
- .2 Provide four (4) pressurized spray cans of matching paint to touch up areas marred during shipping and installation.

2.18 Engine Exhaust Silencer

- .1 Provide flexible hose connection for exhaust silencer contained in Packaged Generator Enclosure.
- .2 Exhaust Silencer:
 - .1 Hospital Grade Hockey Puck type with 70 dBA noise reduction
 - .2 Aluminized steel with 50mm (2 in) thermal insulation,
 - .3 Welded and finished with high temperature black paint
 - .4 Bottom dual inlet and top outlet configuration
 - .5 12 mm (1/2 in) nominal diameter drain
 - .6 Max. pressure drop: 2.0 kPa (8 inwg)
- .3 Expansion joints shall be provided.

Standard of Acceptance

- JP Environmental
- Silex
- York

2.19 Engine Control Panel Section

- .1 Engine mounted control panel to be enclosed with dead front code gauge steel. The enclosure to be shielded in such a way as to prevent sprinkler liquid from entering into the electrical equipment and/or interfering with its operation in compliance with Electrical Safety Code Rule 26-008. A top drip shield shall overhang the perimeter by approximately 0.5 metres and shall be sloped to shed water. Penetrations on top for cables and conduits to be watertight via threaded hubs.
- .2 For the generator, provide form "C" dry contacts wired to a separate terminal strip in the panel for connection to the building automation system by Division 20 for monitoring of the following conditions.
 - .1 engine running
 - .2 engine trouble warning (idle), including:
 - (a) low coolant level
 - (b) low coolant temperature
 - (c) starting battery charger summary alarm
 - (d) fuel leakage detection
 - (e) low fuel level
 - (f) damper breaker open
 - (g) system not in auto
 - (h) control power battery charger summary alarm
 - .3 engine trouble warning (running), including:
 - (a) low lube oil pressure
 - (b) generator breaker open

- (c) damper breaker open
 - (d) high lube oil temperature
 - (e) high coolant temperature
 - (f) low fuel level
 - (g) low voltage – control power
 - (h) alternator over temperature
 - (i) ground fault alarm
 - (j) exciter diode failure
 - (k) under frequency
 - (l) over frequency
 - (m) undervoltage
 - (n) fuel oil filter clogged
- .4 engine shut down alarm, including:
- (a) low lube oil pressure (shutdown level)
 - (b) high coolant temperature (shutdown level)
 - (c) overspeed
 - (d) underfrequency
 - (e) undervoltage
 - (f) overcrank
 - (g) overvoltage
 - (h) emergency stop
- .3 Provide two (2) form “C” dry contacts wired to a separate terminal strip in the panel for connection to the Fire Alarm System by Division 26 for monitoring of the following conditions:
- .1 Engine generator set Summary Trouble alarm (all warning conditions)
 - .2 Engine generator set Summary Shutdown alarm (all shutdown conditions)
 - .3 Engine Running status
- to indicate on the fire alarm system annunciator.
- .4 The control panel to include a programmable logic controller or a purpose built microprocessor based controller and is to include, but not be limited to, the following components:
- .1 control system to initiate the diesel starting and stopping sequence, and annunciate any fault condition (local or remote indication);
 - .2 all required secondary and control wiring, type 'TEW' 105°C rated, extra flexible wire with thermoplastic insulation and an overall flame retarding cotton braid, neatly harnessed, suitably secured and identified with slip-on identification markers; Wiring shall be colour coded to suit application and standards; Note that wiring for the DC supply to control panel, wiring for cranking circuits and wiring for air box damper to be stranded minimum #10 AWG; wiring within control panel shall be stranded minimum #16 AWG; and wiring between control panel and engine generator set shall be stranded minimum #14 AWG.
 - .3 Each cell to be complete with all required control wiring and terminal blocks. Control wiring to be neatly harnessed and suitably secured. Wiring to outgoing circuits and to door mounted equipment shall terminate on terminal blocks.
- .5 The designer/manufacturers of the entire control system will be required to:
- .1 supply complete design, erection and layout drawings for the system, clearly indicating to all wiring requirements, interfacing or interconnection provisions required to completely integrate the controls with all remote apparatus;
 - .2 assemble, wire and pretest the system components in their factory prior to shipment to the engine supplier for factory testing.

- .3 assist in the installation and oversee the work to ensure that it meets with his requirements;
- .4 carry out a site test of the system in conjunction with the other components in the standby power system and demonstrate its proper operation to the satisfaction of the Consultant.
- .6 Selector and Control Switches per Engine
 - .1 Engine Control Selector Switch one (1) engine selector switch for 'MANUAL/OFF/AUTO/RESET' operation. Switch in 'OFF' position shall cause an alarm to occur
 - .2 Illuminated Pushbutton - Alarm Silence
 - .3 Pushbutton - Lamp Test
 - .4 Shrouded Pushbutton - Emergency Stop
 - .5 Shrouded Breaker Control Switch
 - .6 Synchronizing Switch
 - .7 Engine Speed Adjust Potentiometer
 - .8 Voltage regulator selector switch
 - .9 Voltage adjust rheostats (two).
 - .10 Generator & Bus Voltage selector switch
 - .11 Start-stop buttons.
 - .12 Audible alarm and silence button.
 - .13 Outer door mounted emergency stop pushbutton (under protective cover).
 - .14 Engine speed trim potentiometer.
- .7 Metering and Instrumentation per engine
 - .1 Programmable logic controller, or purpose designed microprocessor based digital generator control system to perform the automatic starting, control, monitoring and shutdown of the individual engine generator set
 - .2 automatic voltage regulator with provision for automatic voltage adjustment as specified
 - .3 radio suppression module (unless suppression with alternator meets Commercial Standards);
 - .4 digital governor and speed control system
 - .5 Digital control system shall include:
 - (a) 3-phase digital ammeter
 - (b) Voltmeter (L-L, L-N)
 - (c) Power factor meter (Average, Phase)
 - (d) Frequency meter
 - (e) engine speed tachometer
 - (f) elapsed time meter ;
 - (g) gauges for oil temperature, oil pressure and engine coolant temperature;
 - (h) kW, KVAR, kVA (Average, Phase, %)
 - (i) kW-hr, kVAR-hr (Total)
 - (j) Excitation Voltage and Current
 - (k) Generator Stator and bearing temperature
 - .6 Multifunction generator protective relay equal to GEC P343
- .8 Event logging with time and date stamps.

- .9 Provision for exporting event logs/storing event logs on a personal computer. Include all necessary allowances for onsite set-up for remote storing of events.
- .10 Status, Alarm and Trip Indication per engine (trouble = function included in summary trouble output contacts; alarm = function to be included in summary alarm output contacts)

Function	Shutdown or Warning Condition	Summary Trouble Condition (Idle)	Summary Trouble Condition (Running)	Summary Alarm Condition
Emergency Stop Activated (Local)	Shutdown			X
Overcrank	Shutdown			X
High Engine Temperature Pre-alarm	Warning		X	
High Engine Temperature Alarm	Shutdown			X
Low Lube Oil Pressure Pre-alarm	Warning		X	
Low Lube Oil Pressure Alarm	Shutdown			X
High Lube Oil Temperature	Warning		X	
Low Lube Oil Level	Warning	X		
Over Speed / Over Frequency	Shutdown			X
Under Frequency	Shutdown			X
Low Coolant Level	Warning	X		
Low Coolant Temperature	Warning	X		
Under Voltage	Shutdown			X
Over Voltage	Shutdown			X
Damper Breaker Open	Warning	X		
Alternator Over Temperature	Warning		X	
Exciter Diode Failure	Warning		X	
Engine Control Switch Not in Auto	Warning	X		
Low DC Voltage (Starting Batteries)	Warning	X		
Battery Charger Failure	Warning	X		
Fuel Leakage Detection	Warning	X		
Generator Breaker Open	Warning		X	
Cool Down Cycle				
Fuel oil filter clogged	Warning		X	
Automatic Transfer System not in auto position	Warning	X		
Ground Fault Alarm (contact wired from ground fault alarm relay)	Shutdown			X
Reverse Power Relay	Shutdown			X

Generator Fault	Shutdown			X
Low DC Voltage (Control Power)	Warning	X		

- .11 Instrument Transformers per engine
 - .1 Potential transformers for voltage regulation.
 - .2 Potential transformers for governor circuits.
 - .3 Potential transformers for metering and instrumentation.
 - .4 Current transformers for governor system
 - .5 Current transformers for metering and instrumentation.
- .12 All instrumentation transformers shall have final ratios, burden and other characteristics selected by the Independent Testing Agent preparing the protection and coordination study. Coordinate final selections with Independent Testing Agent.
- .13 Current transformers to have positive action automatic short circuiting devices in secondary terminals.
- .14 Colour coding wiring (D.C. - Blue, A.C. - Black, Dry Contact - Yellow), and necessary instrument transformers, nameplates, bus and terminal blocks.
- .15 120 V secondary instrumentation power transformer, dedicated 1500 VA capacity, for operation of intake and combustion air dampers, primary terminals connected to main bus with HRC fuse protection, complete with a 15A, 120V relay with 2 N.O. and 2 N.C. contacts arranged to accept an external 120V power source from local receptacle panel, for redundant power to dampers.

2.20 Remote Monitoring System

- .1 Provide a cloud-based remote monitoring system complete with all hardware, gateways, power supplies, licenses, etc., as required, connected, set up and configured for the following.
- .2 Communicate each genset's telemetry data to the cloud using an SSL encrypted secure channel.
- .3 Notify the owner via email of warnings, faults, and maintenance alerts. Notification to include all details of an event: time stamp, source, event type, and description.
- .4 Store all telemetry data and event logs on the cloud on a cloud-based server and allow owner to view data and event logs remotely from multiple devices using the web and mobile app.
- .5 Web app shall have data trending capability including graphing of selected parameters from any genset's stored data log over a selectable time period. Allow data exports in CSV format. Provide multiple user-access levels on the web application for the owner, and configure the web dashboard in accordance with owner-defined criteria during commissioning.

2.21 Genset-Mounted Main Breaker

- .1 Provide a genset-mounted circuit breaker for:
 - .1 Generator protection,
 - .2 disconnecting and isolating the generator, and
 - .3 overcurrent protection of the generator feeder cables
- .2 Circuit breaker:

- .1 Listed to UL 489
- .2 Instantaneous override value greater than the maximum available fault current of the alternator.
- .3 Integral electronic trip unit with:
 - (a) True RMS sensing
 - (b) Adjustable long time pick-up and adjustable time delays including I^2t and I^4t
 - (c) Adjustable short time pick up and adjustable time delays including flat response and I^2t
 - (d) Adjustable instantaneous pick up with "off" position
 - (e) Zone-selective interlocking feature
 - (f) Integral digital meter with local display of the following:
 - Current: present and peak individual phase currents and ground current
 - Voltage
 - Power: present and peak values for kW, kVA and kvar
 - Energy
 - Power factor
 - In addition to all of the above functions, main breaker trip unit to display current and voltage total harmonic distortion, individual current and voltage harmonic components up to 31st harmonic, and be capable of waveform capture at a resolution of at least 58 points per cycle.

2.22 Finish

- .1 Finish control panel as follows:
 - .1 basic rust-inhibiting metal process
 - .2 2 coats of powder coat finishing paint.
- .2 Manufacturer to provide quart of touch-up paint or several pressurized spray cans to touch-up small areas marred during installation.

2.23 Equipment Identification

- .1 Provide equipment identification on generator, control panel, and all indication and control devices consisting of engraved, high quality plastic nameplates with black letters suitably inscribed on white background.
- .2 Engraved letters to be 12mm minimum, except 6mm minimum height may be provided for meters, relays, switches, signal lights, keys and key blocks, and all other devices.
- .3 All terminal blocks to have permanent labels.
- .4 All control cables shall be clearly identified, at both ends, with permanent PVC wire markers, indicating Cable Number and wire numbers.

2.24 Phase Designation

- .1 Coloured phase designations or numbering markings to be readily visible in each bus compartment, current transformer compartment, circuit breaker compartment and line and feeder cable compartment.

2.25 Control and Secondary Wiring

- .1 Control and secondary wiring shall be enclosed in metallic raceway insofar as practical. Wiring to outgoing circuits, at shipping splits and devices mounted in hinged instrument panels, shall terminate at terminal blocks.
- .2 Terminal blocks to have numbered points for circuit identification. Terminal blocks to be General Electric Type EB or equal. Terminal blocks for current circuits to be shorting block type.
- .3 Wiring to be type 'TA', 'TBS', or 'SIS', flame retardant #14 AWG size single conductor minimum, stranded, tinned copper, extra flexible type throughout. Wires to be tagged at both ends with permanent plastic sleeve type markers. Insulation to be 600 V, working and 1500 V test.
- .4 Secondary and control wiring within the rear bus compartment shall be completely shielded in a protective metal covering as far as practical.
- .5 Fuse and terminal blocks to be easily accessible. Fuses to be Class J HRC. DC fuses (one per pole) to be in dead front enclosure.
- .6 Auxiliary wiring checks to be made throughout the manufacture and assembly of the equipment to assure wiring correctness and continuity.
- .7 Final checkout of wiring to be made with the complete assembly to assure wiring correctness and continuity. Polarity of current and potential transformers and devices to be checked to assure proper functioning of all protective devices and instrumentation.

2.26 Instrument Transformers

- .1 Potential transformers and current transformers required to operate relays, meters and other devices indicated in the drawings and specifications to be coordinated so that the ratio and accuracy are suitable for each individual application, taking into account the burdens imposed. Construction of transformers to conform to ANSI Standards. All terminals to have permanent polarity designations and to be wired accordingly. All applicable requirements of ANSI Standard C57.13 shall apply.
- .2 Primary potential bus or cable tap leads to be designed with the same design integrity as the primary bus.
- .3 Both current and potential transformers to be wired through test switches to provide quick and easy multi-circuit testing of switchboard relays, meters and instruments.

2.27 Potential Transformers

- .1 Potential transformers shall be housed in a separate compartment in the circuit breaker cubicle or superstructure.
- .2 Potential transformers to be of the 0.3 accuracy class, per ANSI Standards and of sufficient capacity to serve the maximum burden imposed.
- .3 Each potential transformer to be protected with current limiting primary fuses, and shall be designed to withstand the basic impulse level of the switchboard.

2.28 Current Transformers

- .1 Current transformers to be easily removable and accessible and of the ring or bar-type.

- .2 Ring-type current transformers to be used where burden and accuracy permit. Primary terminals on bar-type current transformers to be silver plated and rigidly (2 bolt minimum) connected to the bus structure.
- .3 Secondary connections of all current transformers to have provisions for short circuiting when not connected to instruments and to be solidly grounded.
- .4 Current transformers to be capable of carrying at least 125% of CT rating continuously and have a short time rating at least equivalent to that of the switchgear bus. Accuracy class: C100/ 0.6 B-1.

2.29 Generator Output Cables

- .1 Power cables interconnecting the generator to the generator control panel, and interconnecting the starting batteries to the engine, shall be extra-flexible locomotive cables installed in cable tray per Section 12-2202 of the Electrical Safety Code with the following characteristics:
 - (a) Type DLO & UL listed as Marine Shipboard Cable
 - (b) CSA Type TC listed
 - (c) CSA FT-4 rated
 - (d) Stranded coated copper, size as indicated, with EPR insulation, and thermoset jacket
- .2 Final connections of all control wiring terminating at the engine or generator to be installed in FT4 jacketed liquid tight flexible conduit.

2.30 Factory Acceptance Test (FAT)

- .1 Supplier shall conduct performance and full load tests in the factory in accordance with this section.
- .2 Conduct Factory Acceptance Testing (FAT) of the generator set including engine, alternator, paralleling switchgear, and accessories in presence of Owner/Engineer.
- .3 Notify Owner/Engineer 10 days in advance of date of factory test.
- .4 Prepare blank forms and check sheet with spaces to record data. At top of first sheet record:
 - .1 Date
 - .2 Generator set serial no.
 - .3 Engine, make, model, serial no.
 - .4 Alternator, make, model, serial no.
 - .5 Voltage regulator, make and model.
 - .6 Rating of generator set, kW, kVA, V, A, r/min, Hz.
- .5 Mark check sheet and record data on forms in duplicate as test proceeds.
- .6 The generator set may be factory tested at unity power factor if the alternator unit has been factory tested at rated power factor and rated load at the alternator manufacturer's facility. A copy of the alternator manufacturer's factory test report shall be provided at the generator set factory test.
- .7 Demonstration of automatic starting and load pickup.
 - .1 Install continuous recorders and record the cold start-up time for the generator to reach stable speed and voltage once remote start signal is applied.

- .2 Cold start-up time of the generator to be less than 8 seconds, to achieve power restoration to hospital vital loads within 10 seconds of failure of normal (utility) power when combined with a 2 second engine-start delay programmed at the automatic transfer switches.
- .3 Demonstrate the ability of the generator to pick up the one-step addition of 80% rated load 9 seconds after remote start signal is applied.
- .8 Demonstration of step-load response.
 - .1 Install continuous recorders and record the voltage and frequency variations during load switching procedures for detailed graphical analysis. Delay each load change until steady state conditions exist. Switching increments to include:
 - (a) No load to full load to no load.
 - (b) No load to 80% load to no load.
 - (c) No load to 50% load to no load.
 - (d) 50% load to 80% load to no load.
 - (e) 40% load to 60% load to no load.
- .9 With 100% site rated full load, operate set for 4 h, taking readings at 30 min intervals, and record following:
 - .1 Time of reading.
 - .2 Running time.
 - .3 Ambient temp in °C.
 - .4 Fuel consumption
 - .5 Lube oil pressure in kPa.
 - .6 Lube oil temp in °C.
 - .7 Engine coolant temp in °C.
 - .8 Exhaust stack temp in °C.
 - .9 Alternator voltage:
 - .10 Alternator current:
 - .11 Power in kW.
 - .12 Frequency in Hz.
 - .13 Power Factor.
 - .14 Battery charger current in A or battery voltage in V.
 - .15 Alternator winding temp.
- .10 After completion of 4 h run, demonstrate following features, shut down devices and alarms: Demonstrate low oil pressure and high engine temperature shutdown devices operation without subjecting engine to these excesses.
 - .1 Over cranking.
 - .2 Low engine temperature
 - .3 High engine temperature.
 - .4 Low lube oil pressure pre-alarm.
 - .5 Low lube oil pressure
 - .6 Over speed.
 - .7 Low fuel (signals less than 2h of fuel remaining)
 - .8 Control switch not in automatic position

- .9 Low battery voltage, or no battery charge.
 - .10 Lamp test
 - .11 Contacts for local and remote common alarm
 - .12 Audible alarm silencing switch
 - .13 Manual remote emergency stop.
 - .14 High alternator temperature.
 - .15 Low coolant level
 - .16 Auxiliary supply tank containment leak sensing
 - .17 Underfrequency
 - .18 Overcurrent
 - .19 Undervoltage
 - .20 Overvoltage: Threshold/set point for testing to be set marginally above nominal voltage but well below the capability of winding insulation, so that overvoltage shutdown feature can be verified..
 - .21 Main disconnect / overcurrent device open
 - .22 All other safety features
- .11 Demonstrate
- .1 Automatic starting of set and automatic transfer of load on failure of normal power.
 - .2 Operation of manual control switch.
 - .3 That battery charger reverts to high rate charge after cranking.
 - .4 Oscilloscope trace of the sine wave generator output 60 cycle. Include copy with FAT report.
- .12 Dismantling and shipment from factory shall not occur until deficiencies have been corrected and the system retested to the satisfaction of the Owner/ Engineer and certified as being acceptable for shipment.

2.31 Acceptance Test (Final On-site Testing)

- .1 A competent Diesel-generator expert to be supplied for as long as is necessary for commissioning and witness testing and for two working days, at a time convenient to Owners, to instruct Owners' staff in maintenance and operation, and in addition to be present during on-site commissioning and acceptance test.
- .2 Engine manufacturer to provide an electric resistor load bank of approximately 120% of full rated load for use during factory and on-site test.

2.32 Site Tests

- .1 General
 - .1 Upon completion of the installation of the emergency power supply system, the installation to be tested to ensure conformity to the requirements of Standard C282 and Z32. Provide Engineer with a minimum of 10 days written notification of the proposed test date.
 - .2 All construction within the diesel generator room is to be completed and the room is to be thoroughly cleaned prior to starting the engine for the first time.

- .3 Provide a portable test load bank and cables of the required capacity to perform the following tests at site.

.2 Operational Test

- .1 With the engine in a "cold start" condition and the emergency load at normal operating level, a power failure shall be simulated by opening all switches or breakers supplying the normal power to the building or facility. The test load is to be that load which is normally served by the emergency power system.
- .2 The operational test shall be continued for one hour after which normal power shall be restored to the building or facility and satisfactory transfer of the load and shutdown of the emergency generating set shall be demonstrated.
- .3 The following data to be observed and recorded:
 - (a) time delay on start
 - (b) cranking time until the engine starts and runs
 - (c) time required to come up to operating speed
 - (d) time required to achieve steady-state condition with all switches transferred to the emergency position
 - (e) time required to synchronize generators
 - (f) voltage, frequency, and amperes at start-up and at any observed change in load
 - (g) Engine oil pressure, water temperature where applicable, and battery charge rate at 5 min intervals for the first 15 minutes, and at 15 minute intervals thereafter
 - (h) time delay on retransfer for each transfer switch
 - (i) time delay on engine cool down and shutdown.
- .4 Following the test prescribed above the emergency generator set shall be subjected to a 4 h 100% load test, using a test load bank to be provided by the engine generator supplier and connected by the Division 26 contractor.
- .5 The building load shall not be used as part of the test load. Full load shall equal the nameplate kW rating of the emergency generator set less applicable derating factors for site conditions. Unity power factor is acceptable for on-site testing, provided that rated load tests at rated power factor have been performed by the manufacturer of the emergency generator set prior to shipment.
- .6 Synchronization Tests
 - (a) Demonstrate the emergency start and synchronizing features of all generators as a system.
 - (b) Demonstrate the automatic operation and control of each transfer switch on the project.

2.33 Load Testing Provisions

- .1 Provision to be made outside of the generator enclosure for permanent connection to a test load, complete with means of disconnect and overcurrent protection, per CSA C282-15. Load bank test box to be located in an outdoor weather proof lockable enclosure and complete with a 120VAC receptacle for load bank controls.
- .2 In the event of a utility outage during load-bank testing, the load bank must be automatically disconnected to allow the emergency generator to support the critical building loads.

Standard of Acceptance

- Toromont Power Care Quick-Connect
- Generac

2.34 Manufacturers/Suppliers

- .1 The suppliers tendering the equipment and services under Division 26 shall include preparation and submission of technical documents listed herein as well as the services of a site technical representative to assist during installation in the performance of commissioning and witness testing program and conduct training of the Owners staff.
- .2 Diesel set shall be as manufactured by one of the following:

Standard of Acceptance

- Toromont (Cat)
- Cummins
- Generac
- MTU

3 EXECUTION

3.1 General

- .1 Provide a complete Diesel-generator set as described above.
- .2 Take delivery of the diesel generator and related equipment. Provide necessary cranes and hoisting equipment and labour to unload equipment from transport and place in designated location.
- .3 Prior to project completion, revise all wiring diagrams submitted as Shop Drawings to "As-Built" condition, prepare photo reductions of same and include them in the Operation and Maintenance Manual.
- .4 Touch up small areas marred in transit or during installation with touch up paint.

3.2 Testing

- .1 Coordinate the services of the Manufacturer's factory trained service representative with the equipment supplier to check the installation, start the generator, calibrate controls and train the Owner's Operators in the proper operation and maintenance of the equipment.
- .2 Unload, handle, install and provide temporary cables from generator control panel to temporary load bank for on-site testing. Note that engine-generator assembler shall supply the load bank for site testing.
- .3 Provide pre-service inspection, testing and calibration of control panel for switchboards, panelboards, and protective schemes prior to energization.
- .4 Verify power and control wiring connections between engine generator, engine control panel and diesel combustion air dampers and ventilation dampers, battery charger and automatic transfer switches
- .5 All construction within the diesel generator room is to be completed and the room is to be thoroughly cleaned prior to starting the engine for the first time.
- .6 Provide Owner/Engineer with a minimum of 10 days written notification of the proposed test date for all tests, including initial equipment startup. Obtain approval prior to startup or testing.

- .7 Upon completion of the installation of the emergency power supply system, and after startup and preliminary tests, the installation shall be tested to ensure conformity to the requirements of CSA Standard C282-19 and the Site Acceptance Testing section below.
- .8 The Site Acceptance Test (SAT) shall be a separate test, as described in the section below, to demonstrate the operation and performance of the complete emergency power system to the Engineer and Owner's project representative(s). Repeat the test if interrupted by inclement weather. In the event of equipment or component failures interrupting completion of test, correct the deficiency and repeat test until satisfactorily completed without failure.
- .9 Remove the load bank and temporary connections after on-site witness tests have been completed successfully.
- .10 Provide all fuel for testing, including the SAT.
- .11 Provide initial filling of day tanks.
- .12 Division 20 contractor shall provide initial filling of main storage tank.
- .13 Demonstrate functioning of safety devices, pilot lights, controls, remote monitoring on the Building Automation System and Fire Alarm system and operation of all interconnections and alarms to battery charger, fuel system, leak detection panel, dampers, Automatic Transfer switches, etc...
- .14 Immediately following the load test a sample of lubricating oil shall be taken for lab analysis.
- .15 After completion of tests replace all air, fuel and lubricating oil filters with new elements and change the lube oil.

3.3 Installation of Miscellaneous Components

- .1 Provide power and control wiring between engine control panel and diesel combustion air dampers and ventilation dampers. Provide 120 V secondary power source from local 120V emergency panel to the control panel switching relay to permit dampers to close when engine shuts down.
- .2 Provide 8 conductor #12 MICC cable from each Automatic Transfer Switch to the diesel generator for engine start contact, ATS in normal position status, ATS in emergency position status, and ATS in bypass position status.
- .3 Provide 4 conductor #12 MICC cable from each Fire Pump ATS/Control Panel, and each Sprinkler Pump ATS/Control panel to the generator for engine start contact and ATS in emergency position status.
- .4 Supply one per engine Remote Emergency Stop mushroom head pushbutton station with lift type guard, with size 6 label, wired to shut down the engine immediately. Contractor to mount outside of room, and wire to control panel.
- .5 Provide connection from control panel to fire alarm panel to indicate engine running and trouble condition on fire alarm annunciator.
- .6 Provide power and control wiring between engine control panel and the diesel fuel tank level controller to obtain "Fuel Low Level" alarm contact.
- .7 Provide control wiring connection between engine control panel and fuel leakage detection system panel.

- .8 Provide control wiring to battery charger and automatic transfer switches for remote monitoring indication on the centralized electrical monitoring system.

3.4 Installation work by the Supplier (Include all costs in the Bid Amount)

- .1 Provide one (1) complete Diesel-generator set and control panel power system. Deliver FOB job site on a flatbed tractor trailer, suitably protected during shipping from the environment.
- .2 A competent Diesel-generator and control systems expert shall be supplied for as long as is necessary, including during startup, preliminary testing, commissioning, and site acceptance testing.
- .3 Verify power and control wiring connections between engine generator, engine control panel and diesel combustion air dampers and ventilation dampers, battery charger and automatic transfer switch.
- .4 Provide temporary cables and temporary load bank for on-site testing, complete with terminal lugs on cables.
- .5 Conduct an acceptance test after preliminary runs and set up / calibration tests have been made. Conduct this test on site after completion of installation. This acceptance test shall be a minimum of four hours duration with full rated load plus verification of the system performance. In the event of equipment or component failures interrupting completion of test, correct the deficiency and repeat test until satisfactorily completed without failure.
- .6 After completion of above test, perform tests to demonstrate overheat protection, low oil pressure protection and over-speed protection. Demonstrate functioning of safety devices.
- .7 After completion of tests replace all air, fuel and lubricating oil filters with new elements and change the lube oil.
- .8 Include costs of the 2 year routine maintenance (with all filters) in bid price.
- .9 Revise all wiring diagrams submitted as Shop Drawings to "As-Built" condition, prepare photo reductions of same and include them in the Operation and Maintenance Manual.

3.5 Site Acceptance Test (SAT)

- .1 SAT to include all the tests described below and the tests required by section 10 of CSA C282-19.
- .2 Intent:
 - .1 Demonstrate proper operation of the new emergency power supply system equipment installed at CMH and the controls integration to the ATSS.
 - .2 Testing to be to be done using a temporary load bank and without utilizing the operational hospital building loads and in a manner that does not disrupt the hospital operations.
 - .3 Conduct a maximum site design load test to demonstrate the overall performance of the new emergency power supply system, including conformance with criteria for emissions, noise and vibration.
- .3 Operational Test
 - .1 With the engine in a "cold start" condition, the generator bus tie breaker open, and the load bank(s) adjusted to 300kW, a power failure shall be simulated by initiating a 'system test' from the new ATS in the new electrical room.

- .2 The test shall demonstrate automatic startup and load pick up within 8 seconds.
 - .3 Install advanced power quality type continuous recorders and/or line disturbance recorders to record the startup time and voltage and frequency variations during startup and step-load tests for detailed graphical analysis.
 - .4 The operational test shall be continued for one hour after which shutdown of the emergency generating system shall be demonstrated.
 - .5 The following data shall be observed and recorded:
 - (a) time delay on start
 - (b) cranking time until the engine starts and runs
 - (c) time required to come up to operating speed
 - (d) time required to achieve steady-state condition with all switches transferred to the emergency position
 - (e) voltage, frequency, and amperes at start-up and at any observed change in load
 - (f) Engine oil pressure, water temperature where applicable, and battery charge rate at 5 min intervals for the first 15 minutes, and at 15 minute intervals thereafter
 - (g) time delay on retransfer
 - (h) time delay on engine cooldown and shutdown.
 - .6 System start up shall be tested from each ATS, existing and new, with engine-start contacts wired to start the generator, to verify the integrity of the start signal circuitry and demonstrate system response. The one-hour run time duration is required only for the simulated start signal from one new ATS.
- .4 Full rated load test
- .1 Following the test prescribed above, each new emergency generator set shall be subjected to a 100% rated load test for 6 hours at 450kW load.
 - .2 Demonstrate that the ventilation system will maintain the room temperature within the allowable tolerances specified in CSA C282-19.
 - .3 Measure the exhaust back pressure at regular intervals and demonstrate that it remains within generator manufacturer specified limits.
 - .4 Record noise levels to demonstrate the installation meets the acoustic and noise level limits for the operation of Emergency Power Generation.
 - .5 Record vibration levels to demonstrate the installation meets acceptable vibration levels.
- .5 Step-load tests
- .1 Voltage and frequency variations during load switching shall be measured for each new generator and recorded as follows:
 - (a) Install continuous recorders to record frequency and voltage variations during load-switching procedures.
 - (b) Delay each load change until steady-state conditions exist.
 - (c) Switch increments to include typical loads such as
 - no load to full load (450kW) to no load;
 - no load to 300kW to no load;
 - no load to 70% load to no load;
 - 40% load to 60% load to no load; and
 - 60% load to 80% load to no load.

END OF SECTION

ENCLOSURES FOR FACILITY POWER GENERATION EQUIPMENT 26 32 43

1 GENERAL

1.1 Scope

- .1 Provide factory fabricated enclosure for facility power generation equipment complete with subbase fuel tank, internal equipment, line equipment and accessories.
- .2 As a separate price, provide factory fabricated enclosure for facility power generation equipment as described in 1.1.1, with a removable subbase fuel tank in lieu of a fixed subbase fuel tank.

1.2 Related Sections

- .1 Without limiting the scope of work or applicability of other specification sections, the work under this section directly integrates with or refers to the following specification sections:
 - .1 26 32 13 Power Generation Diesel

1.3 Definitions and Abbreviations

- .1 The following definitions apply to this section.
 - .1 **Equipment Enclosure** – a housing that can provide structural support, sound attenuation, security, and weather protection.

Skin-tight enclosure – an enclosure that does not require personnel to be inside the enclosure for operation or regular maintenance of the equipment.

Walk-in enclosure – an enclosure requiring personnel to be inside the enclosure to perform maintenance or operations work.
 - .2 **Fuel gas** – means natural gas or propane gas.
 - .3 **Shore services** – electrical and mechanical services supplied by one or more building service to the enclosure for operation of equipment inside the enclosure.

Shore power – a shore service consisting of electrical power supplies
- .2 Abbreviations
 - .1 EGSA Engine Generating Systems Association

1.4 Applicable Codes and Standards

- .1 Installation codes and standards:
 - .1 CSA B139 Installation Code for Oil Burning Equipment
 - .2 OESC Ontario Electrical Safety Code
 - .3 CSA C282 Emergency Electrical Power Supply for Buildings
 - .4 EGSA 200W Recommended Practice for Seismic and Wind Certification for Compliance to the International Building Code (IBC)

1.5 Registration and Inspection

- .1 Arrange and pay for variances and inspections by applicable authorities having jurisdiction where the enclosure and applicable equipment are not certified as a complete assembled product:
 - .1 electrical safety,
 - .2 fuel safety.

- .2 Apply and pay for the following variance or special permissions related to fuel safety (apply by mechanical consultant and reviewed by TSSA):

- .1 Valves listed to UL 842, including valves larger than NPS 2 and motorized control valves,
- .2 Use of FM approved fusible link valves,
- .3 Day tank venting to atmosphere to be reviewed by TSSA

1.6 Design Criteria

- .1 General:
 - .1 Foundation condition or support: concrete pad at grade.
- .2 Environmental design criteria.
 - .1 Outdoor winter design temperature: -30°C (-34.4°F)
 - .2 Outdoor summer design temperature: 32.2°C (90°F)
 - .3 Winter minimum interior space temperature: 10°C (50°F)
 - (a) prior to engine operating.
 - .4 Summer maximum interior space temperature: 40°C (104°F)
 - (a) when engine operating at maximum rated capacity after 2 hours,
 - (b) measured 150 mm (6 in) above the generator control panel at inlet to engine radiator.
- .3 Interior equipment access criteria – walk-in units:
 - .1 Access door to be sized for general service
 - .2 Removable panel for major equipment service
- .4
- .5 Acoustic performance criteria:
 - Overall 53 dBA 7 m away.

1.7 Submittals

- .1 Shop drawings:
 - .1 Submit enclosure unit layouts drawn to scale showing
 - (a) details of enclosure construction,
 - (b) support and connection details,
 - (c) equipment weight,
 - (d) component identification using numbering and type designations taken from contract drawings, specifications, and schedules, and
 - (e) component locations identified in plan and section.
 - .2 Submit component shop drawings and manufacturer's data sheets in accordance with requirements set out in the Specification sections identified above showing;
 - (a) component identification,
 - (b) manufacturer's equipment model numbers,
 - (c) component performance and design data,

- (d) component outline dimensions, and
 - (e) power requirements,
- .3 Submit control and power wiring schematics and single-line drawings.
- .4 Submit manufacturer catalogue cut-sheets for the following materials;
 - (a) Auxiliary supply tank
 - (b) Air intake and exhaust silencer
 - (c) Dampers & actuator
 - (d) Exhaust fan
 - (e) unit heaters
 - (f) louvres
 - (g) Combustion exhaust muffler
 - (h) Fire protection system
 - (i) Fuel oil return pump
 - (j) Fuel oil strainer

1.8 Quality Control

- .1 Equipment enclosure prototype weather test:
 - .1 Prototype of enclosure design has been subjected to a rain test in accordance with UL/ULC 2200 or CSA B138.1. Submit manufacturer's declaration of this test with the shop drawings.
 - .2 Exception: if equipment enclosure has been certified to UL/ULC 2200 or CSA B138.1.
- .2 Manufacturer Production Test and Records:
 - .1 Submit certified copies of reports of manufacturer's production testing for the following equipment:
 - (a) engine-generator sets.
- .3 Manufacturer Factory Acceptance Testing (FAT):
 - .1 FAT to be performed in the presence of contractor's representative(s) for each tested equipment or system.
 - .2 FAT are in addition to manufacturer's standard production tests.
 - .3 Deficiencies discovered during FAT will be corrected prior to shipping of product.
 - .4 Conduct FAT for enclosures which includes the following tests:
 - (a) external noise attenuation test.
 - .5 Submit copies of completed FAT test result documentation to Contractor and Consultant..
- .4 Site Acceptance Testing
 - .1 Manufacturer to provide services of manufacturer's authorized service personnel to in accordance with the requirements of Part 3 of this specification.

2 PRODUCTS

2.1 General

- .1 Factory assembled equipment walk-in enclosure, including base, frame, wall and roof casings, access doors, equipment, components and accessories specified herein and as shown.
- .2 Enclosure shall be provided by Engine-Generator vendor as selected in 26 32 13 to ensure compatibility between components.

2.2 Seismic Control

- .1 Design entire enclosure, including all equipment and services contained therein, to withstand seismic movement generated forces and displacement, and to allow equipment and services to remain functional after the seismic event.
- .2 Equipment to be seismic certified to withstand the ground acceleration criteria and seismic demand requirements for nonstructural equipment as identified in the Ontario Building Code for the geographic location of installation
- .3 Equipment to be designed, certified and installed in accordance with the International Building Code (IBC) chapters 16 and 17.
- .4 Provide signed and sealed drawings as well as field reports from a professional seismic engineer, registered in Ontario. Obtain certification for "seismic withstand capability" and, to maintain the certification, anchor such equipment according to the manufacturer's instructions.

2.3 General Materials

- .1 Galvanized steel:
 - .1 ASTM A-527 lock-former quality
 - .2 ASTM A525-75 designation G90 class for unpainted surfaces,
 - .3 satin coat steel for painted surfaces.
- .2 Stainless Steel:
 - .1 type 304/304L to ASTM A480 Specification for General Requirements for Flat Rolled Plate, Sheet and Strip
- .3 Aluminum:
 - .1 Type 3003-H-14,
- .4 Casing and roof insulation:
 - .1 50mm (2") thick Mansville "Permacoate Linacoustic R-300", or
 - .2 50mm (2") thick fibreglass 48 kg/m³ (3 lb/ft³) density, covered with neoprene.
 - .3 Flame spread rating ≤ 25 when tested in accordance with CAN/ULC-S102.2.

2.4 Enclosure Unit Construction

- .1 Base frame:
 - .1 minimum 200 mm (8 in) high, welded structural steel or formed channels in ladder configuration with cross members at ends and under major equipment concentrated load points.
 - .2 fitted with lifting lugs, and
 - .3 designed to evenly distribute unit weight to unit support points, or to be continuously supported.
 - .4 where unit is shown to be supported on a steel support system, unit structural base to be designed to transfer unit load to support points as shown.
 - .5 SEPARATE PRICE ITEM – Provide separate pricing for the base frame to allow for fuel tank removal. Structural frame must support generator enclosure independent of fuel tank. Design frame to support fuel tank and provide channels or additional structure as necessary to allow for tank to be drawn out from below enclosure, and for the same tank or a new tank to be replaced. Structural frame must allow for disconnection and reconnection of fuel pipes and hoses to both the fuel tank as well as the generator fuel lines. Structural frame is to be designed to permit the fuel tank to be removed horizontally and must provide sufficient clearances to allow this to occur.

- .2 Floor:
 - .1 reinforced, minimum 3 mm (0.125 in) aluminum, checker plate, designed to prevent "oil canning",
 - .2 50 mm (2 in) insulation on underside of floor, with 0.8 mm (22 ga) bottom panel on the underside of the insulation, caulked and sealed,
 - .3 Integral floor containment curb around the inside perimeter of the unit, of sufficient height to contain 10% of the capacity of the fuel tank volume, but not less than 150 mm (6 in.) high,
- .3 Wall and roof construction:
 - .1 exterior wall and roof constructed from insulated sandwich panels,
 - .2 designed to support internal equipment and service loads as necessary, or alternatively provide a post and frame structure to support internal equipment and services independently of the wall and roof panels,
 - .3 50 mm (2 in) thick, with tongue and groove or 'C' type jointing,
 - .4 maximum panel width 660 mm (26 in),
 - .5 fastened at maximum 300 mm (12 in) centres to intermediate ribs and structural framing, reinforced and braced for rigidity,
 - .6 outer skin: 1.6 mm (16 ga), galvanized steel
 - .7 inner skin: 0.8 mm (22 ga), perforated galvanized steel, 22% open free area,
 - .8 roof outer skin:
 - (a) formed by panels joined by standing seams with weather caps.
 - (b) sloped minimum 1 in 80 across width of unit in one direction.
- .4 Enclosure subbase fuel tank:
 - .1 shall have a double wall construction sub-base fuel tank, UL listed with 72 hours capacity at site maximum demand load. Level gauge, low level switch, vent cap, fill cap, leak alarm switch shall be provided in the fuel tank. Provide fuel filtering and polishing to meet fuel quality and capacity requirements.
 - .2 Provide level switches in tank to provide:
 - (a) tank high level alarm to BAS thru generator control panel.
 - (b) tank low level alarm to BAS thru generator control panel.
 - (c) Fuel fill alarm at fill point.
 - .3 SEPARATE PRICE ITEM: Provide separate pricing for provision of a removable double wall construction subbase fuel tank in lieu of a fixed fuel tank. Fuel tank is to be designed to provide 72 hours of fuel for maximum site design load, and is to be located below walk-in enclosure. Fuel tank is to be designed to be drawn out from below enclosure to allow for cleaning and/or replacement. Fuel pipe connections are to be readily accessible and are to be designed in such a way to allow for disconnection and reconnection to facilitate tank replacement. Fuel tank is to form no part of the support structure of the enclosure and generator. Provide multiple vessels as required to allow for fuel tank removal. Fuel tank must meet all other requirements set out in paragraph 2,4,4(1) and (2).
- .5 Access doors:
 - .1 number of access doors:
 - (a) walk-in enclosures: as required to allow access for service and maintenance, removal, and replacement of all equipment located inside the enclosure without requiring removal of other equipment, but not less than one (1)
 - (b) skin-tight enclosure: as required to allow access to service and maintain all equipment inside the enclosure without entering the enclosure.
 - .2 door dimensions:

- (a) overall height: maximum height possible to suit enclosure height but not exceeding 2.0 m (80 in.)
- (b) sill height: not lower than the required floor containment curb height,
- (c) width: to be not less than 600 mm (24 in) and to be sized to permit day tank removal.
- .3 door construction:
 - (a) double wall construction, as described for wall panel,
 - (b) 1.6 mm (16 ga) formed channel trim with welded corners,
 - (c) mounted in matching 1.6 mm (16 ga) welded casing channel frame with continuous angle stop,
 - (d) continuous stainless steel piano hinge or two butt hinges, welded to door and casing frame.
 - (e) key-lockable stainless steel door hardware, with mechanism to override lock from within the unit,
 - (f) provision for card access on exterior of enclosure at both doors,
 - (g) two stainless steel exterior grip handles,
 - (h) doors to open outwards,
- .6 Casing finish:
 - .1 paint external galvanized surfaces with one coat of phosphate vinyl wash primer, finished with two part blend of bond primer and alkyd or epoxy enamel paint.
 - .2 finish colour: to be selected from standard range of products submitted with shop drawings.
 - .3 paint interior un-galvanized steel parts with corrosion resistant primer and top coat
- .7 Service penetration sleeves:
 - .1 40 mm (1½ in) high aluminum or stainless steel watertight flashing collars at service penetrations through floor, roof and walls.
- .8 Air louvres:
 - .1 flush wall mounted on exhausts and air intakes;
 - .2 material: aluminum 6063-T5 fixed louvre blades set at 45 angle, on 100 mm (4 in) centres,
 - .3 drainable type for air intake and exhaust louvres,
 - .4 frame: aluminum 6064-T5 100 mm (4 in) wide,
 - .5 finish: same as unit casing finish,
 - .6 bird screen: galvanized steel, 12 mm x 12 mm (½ in x ½ in) openings, fastened to rear with cadmium plated screws,
 - .7 size:
 - (a) air intakes: not to exceed 2.0 m/s (400 fpm) core (face) velocity,
 - (b) exhaust: not to exceed 2.5 m/s (500 fpm) core (face) velocity,
 - (c) exception: higher air intake velocities are permitted where manufacturer can demonstrate correction functionality of the unit at resulting higher static pressure.
 - .8 bottom edge of louvred opening at least 900 mm (30 in), above base of unit.
- .9 Air intake cowls:
 - .1 externally mounted on air intakes and exhausts,
 - .2 multi-sectioned, structurally reinforced,
 - .3 material: 1.6 mm (16 ga) galvanized steel, cross broken for rigidity, and
 - .4 finished with formed perimeter drip gutter,
 - .5 bottom edge of intake opening at least 1.2 m (4 ft) above roof,

- .6 bird screen: galvanized steel wire mesh with 12 mm x 12 mm (½ in x ½ in) openings, fastened to 1.6 mm (16 ga) galvanized reinforcing framing with cadmium plated screws.

2.5 Power and Shore Services Connections and Terminations

- .1 General:
 - .1 Locate shore service interface points as specified herein.
 - .2 Provide factory wiring, and empty conduit for electrical shore services as specified herein.
 - .3 Terminate fuel piping for connection to external fuel systems as specified herein.
- .2 Generator power cables:
 - .1 Locate generator power cable entry point on sidewall of unit.
 - .2 Provide a pathway inside the unit from the cable entry point to the generator.
- .3 Shore power service:
 - .1 Locate shore power feeder entry point on sidewall of unit.
 - .2 Provide a pathway inside the unit for a 41mm conduit from the cable entry point to the panel.
- .4 Engine command/control service:
 - .1 Locate engine control wiring entry point on sidewall of unit.
 - .2 Provide junction box within the enclosure for connection of start signals.
 - .3 Provide two Ø25 mm empty conduits between the junction box at the point of entry to the enclosure.
- .5 Engine remote monitoring service:
 - .1 Locate remote monitoring service wiring entry point on sidewall of unit.
 - .2 Provide junction box within the enclosure for remote monitoring cabling.
 - .3 Provide Ø25 mm empty conduit between the junction box at the point of entry to the enclosure, and between the junction box and generator control panel.
- .6 Fire alarm service:
 - .1 Locate fire alarm wiring entry point on sidewall of unit.
 - .2 Provide an Ø25 mm empty conduit between the first fire detection device and a junction box at the point of entry to the enclosure.
- .7 Building management control system service:
 - .1 Locate building management control wiring entry point on sidewall of unit.
 - .2 Provide an Ø25 mm empty conduit between the DDC controller and a junction box at the point of entry to the enclosure.
- .8 Fuel oil piping:
 - .1 Locate fuel oil piping entry point at sidewall or underside of unit.
 - .2 Provide fuel oil supply and return piping from the subbase fuel oil tank to the point of entry and terminate with a flange.

2.6 Electrical Generation Equipment

- .1 Provide one enclosure per engine-generator unit.
- .2 Engine-generator units to conform to Specification section 26 32 13.

2.7 Enclosure Electrical Services

- .1 Shore Power
 - .1 The enclosure shall be provided with an internal load-centre panel board rated for 100A, 208V, 3-phase, 4-wire, 18kAIC, with sufficient quantity of 1-pole, 2-pole or 3-pole branch breakers as required, pre-wired to all auxiliaries within the enclosure.
 - .2 The panelboard shall be surface-mounted CSA Type 2, with a hinged, lockable door.
 - .3 The placement of this panelboard shall be shown on the submittal drawings.
 - .4 The panelboard shall be mounted within the enclosure and allow for a single top-entry point for incoming power supply conduit and wiring by the installing contractor.
 - .5 A 100A, 208V, 3phase, 4W, emergency power feed will be provided from the hospital building to the enclosure for shore power requirements within the enclosure.
 - .6 Provide local disconnect switch in enclosure immediately upstream for shore power panel to allow isolation.
- .2 All internal conduit and wiring to the various ancillary equipment supplied with the package and shall be pre-wired by the packager in accordance with all governing codes pursuant to this application.
- .3 Heaters shall be provided in each item of electrical equipment to prevent condensation. Strip heaters shall be thermostat controlled and pre-wired using #14 AWG tinned copper, extra flex, 600 volt insulation, thermo-plastic insulated, cotton braid covered type TSB in grounded conduit. Strip heaters shall be rated for 120 volts and grouped into 15 amp circuits which shall be connected to the load-centre internal to the enclosure.
- .4 Wiring shall be copper with RW90 insulation.

2.8 Remote Monitoring System

- .1 Provide empty Ø25 mm conduit and boxes between enclosure exterior and generator control panel to allow for installation of control wiring for cloud-based remote monitoring of generator operation.

2.9 Lighting System

- .1 Internal Lighting:
 - .1 General illumination in enclosure shall be provided by LED fixtures.
 - .2 Provide three-way switches located at each entry door.
 - .3 Provide power to interior lights from shore panel
- .2 Exterior Lighting:
 - .1 Provide one exterior LED wall-pack luminaire at each entrance door to enclosure.
 - .2 Exterior luminaires shall be full-cutoff type.
 - .3 Provide integral or external photocell for control of exterior luminaires. One photocell may serve all luminaires on the enclosure
 - .4 Provide power to exterior lights from shore panel. Interior and exterior lights may share same circuit
- .3 Unit Equipment for Emergency Lighting:
 - .1 Emergency battery lighting with 2-hour battery backup shall be provided within the enclosure. Unit equipment shall be listed CSA Standard 22.2 No. 141. Battery shall be dedicated for emergency lighting. Equipment shall be suitable for a supply voltage of 120V and provide output voltage at 24V DC.

- .2 Provide a total of 4 lamp heads within the enclosure, 2 along each maintenance aisle. Lamp heads shall be integral on unit and remote, capable of 360° horizontal and 180° vertical adjustment. Lamps shall be LED, with greater than 300 lumens each.
- .3 Provide dedicated circuit from shore panel to power emergency and exit signs.
- .4 Exit Signs
 - .1 Provide LED exit signs internal to the enclosure.
 - .2 Exit signs shall be listed to CSA Standard No. C860.
 - .3 These shall be located above doors and wired to the same 120V shore power circuit as the emergency lighting equipment above.

2.10 Convenience and Maintenance Receptacles

- .1 Provide a minimum of two (2) CSA type 5-20R (T-slot) type receptacles within each enclosure for maintenance and servicing of equipment within the enclosure
- .2 Provide power to receptacles from shore power panel.

2.11 Signage and Warning Systems

- .1 Provide safety and warning signage as required by applicable codes and standards, including, but not limited to
 - .1 Shock and Arc Flash labels on equipment within enclosure
 - .2 Automatic start warnings on each door into enclosure.

2.12 Fire Detection System

- .1 Provide fire detection devices as required for operation of base building fire alarm system
- .2 Provide terminal strip for connection of status, trouble and alarm signals for connection to base-building fire alarm system by others.

2.13 Diesel Fuel Systems

- .1 Provide aboveground fuel oil piping, valves, specialties and accessories for stationary engines including diesel-generators.
- .2 Submit manufacturer's data sheets for valves, flange gaskets and oil specialties, with model numbers, performance and design data, outline dimensions and power requirements.
- .3 For equipment required to be listed (certified) to a standard, shop drawings shall include the following information marked on the data sheet:
 - .1 the standard to which it is listed,
 - .2 name of testing organization or their recognized mark, and
 - .3 the testing organization testing Class and/or listing file.
- .4 Legislation:
 - .1 Ontario:
 - (a) Regulation 213/01 Fuel Oil
 - (b) Regulation 215/01 Fuel Industry Certificates
 - (c) Regulation 216/01 Certification of Petroleum Mechanics
- .5 Installation standards and codes:
 - .1 Provincial: CSA B139 *Installation code for oil-burning equipment*, edition as adopted and amended by the AHJ.

- .2 Factory Mutual Data Sheet 7-32 *Ignitable Liquid Operations*
- .6 Product standards:
 - .1 ASTM A53 Standard Specification for Pipe, Steel, Black and Hot Dipped, Zinc-Coated, Welded and Seamless.
 - .2 ASTM A106 Standard Specification for Seamless Carbon Steel Pipe for High Temperature Service
 - .3 ASTM A194 Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High-Pressure or High-Temperature Service, or Both
 - .4 ASTM A307 Standard Specification for Carbon Steel Bolts and Studs, 60 000 PSI Tensile Strength
 - .5 ASTM A563 Standard Specification for Carbon and Alloy Steel Nuts
 - .6 ASME B16.3 Malleable Iron Threaded Fittings
 - .7 ASME B16.5 Pipe Flanges and Flanged Fittings
 - .8 ASME B16.9 Factory Made Wrought Steel Buttwelding Fittings
 - .9 ASME B16.11 Forged Fittings, Socket-Welding and Threaded
 - .10 ASME B16.39 Malleable Iron Threaded Pipe Unions: Classes 150, 250 and 300
 - .11 ASME B18.2.1 Square and Hex Bolts and Screws
 - .12 ASME B18.2.2 Square and Hex Nuts
 - .13 ASME B16.21 Non-Metallic Flat Gaskets for Pipe Flanges
 - .14 ASME B16.20 Metallic Gaskets for Pipe Flange: Ring-Joint Spiral Wound and Jacketed
 - .15 ULC/ORD C536 Flexible Metallic Hose
 - .16 ULC/ORD C842 Guide for the investigation of valves for flammable and combustible liquids
 - .17 ULC S631 Isolation Bushings for Steel Underground Tanks Protected with External Corrosion Protection System
 - .18 CAN/ULC S661 Standard for Overfill Protection Devices for Flammable and Combustible Liquide Storage
 - .19 CAN/ULC S663 Standard for Spill Containment Devices for Flammable and Combustible Liquid Aboveground Storage Tanks.
 - .20 MSS SP-97 Integrally Reinforced Forged Branch Outlet Fittings – Socket Welding, Threaded, and Buttwelding Ends
 - .21 UL 842 Valves for Flammable Liquids
 - .22 FM Class 7440 Approval Standard for Liquid and Gas Safety Shut-off Valves.
- .7 Submit applications, as required, and arrange and pay for field inspection of the installation by the Authority Having Jurisdiction including:
 - .1 Ontario:
 - (a) Registration of High Pressure piping system,
 - (b) Inspection of underground tanks and underground fuel piping,
 - (c) Field inspections for variances issued by the AHJ.

- .8 The Engineer has submitted an application for approval with the Authority Having Jurisdiction for the following alternative solutions. Contractor shall submit an application, and arrange and pay for field inspection by the Authority Having Jurisdiction.
- .9 Installation and on site testing of fuel oil systems to be performed in accordance with applicable regulations and standards by a specialist licensed petroleum equipment contractor of the applicable class for the equipment.
- .10 Piping system design criteria:
 - .1 Low pressure:
 - (a) Design pressure: 690 kPa (100 psig)
 - (b) Design temperature: 38°C (100°F)
 - .2 The following piping systems are classified as Low Pressure:
 - (a) Supply tank fill and vent piping.
 - (b) Suction piping between a supply tank and a transfer pump.
 - (c) Supply and return piping between an auxiliary supply tank and a stationary engine.
 - (d) Supply tank external fuel polishing system piping where piped independently of other system piping.
 - .3 The following piping systems are classified as Low Pressure except where otherwise shown on drawings, in whole or in part, as being High Pressure:
 - (a) Fuel supply piping commencing on the discharge side of a transfer pump,
 - (b) Fuel return from a heating appliance, an auxiliary tank overflow pipe, or a return pipe directly from a stationary engine to the main supply tank.
 - (c) Transfer pump pressure relief valve piping.
- .11 Piping Code:
 - .1 Low Pressure piping:
 - (a) ASME B31.9 Building Service Piping Code
 - .2 High Pressure piping:
 - (a) ASME B31.1 Power Piping Code

2.14 Steel Pipe and Fittings

- .1 General:
 - .1 Pipe fittings and flanges:
 - (a) Canadian Registration Number (CRN) listing,
 - (b) manufactured by an ISO9001 certified company.
- Standard of Acceptance*

 - Anvil
 - Bonney Forge
- .2 Pipe:
 - .1 NPS ½ to 10:
 - (a) ASTM A106 Gr B, schedule 40 Seamless, or
 - (b) ASTM A53 Gr B, schedule 40 Electric Resistance Weld (type E) or Seamless (type S)
 - .2 For vent piping located outdoors: as specified above and wither with galvanized coating unless piping is field painted.
- .3 Fittings:

- .1 NPS 2 and under:
 - (a) Class 3000 forged steel fittings, socket welding type, to ASME B 16.11,
 - (b) Class 300 malleable iron threaded fittings, to ASME B16.3,
 - (c) Class 300 black malleable iron, bronze face, ground joint unions, to ASME B16.39.
- .2 Tank vent piping, NPS 2 and under:
 - (a) As specified above, or Class 150 malleable iron threaded fittings, to ASME B16.3.
- .3 NPS 2 ½ and over:
 - (a) Class 3000 forged steel fittings, socket welding type, to ASME B 16.11,
 - (b) Buttweld type fittings, long radius elbow, wall thickness to match pipe, to ASME 16.9,
- .4 Branch outlet fittings:
 - (a) Standard Class integrally reinforced branch outlet fittings for buttweld branch connection to MSS SP-97.
- .4 Flanges:
 - .1 NPS ½ and over:
 - (a) Class 150 (Class 300 where shown) forged steel raised face flanges, to ASME B16.5,
 - (b) weld-neck with wall thickness to match pipe, or slip on type.
 - .2 Gaskets:
 - (a) To ASME B16.21 of heavy- duty graphite impregnated compressed sheet 1.6 mm (1/16 in) thick
 - (b) Minimum service temperature: 600°C (1110°F).

Standard of Acceptance

 - Chesterton 198- .3 Studs, bolts and nuts:
 - (a) "High strength" type to ASME B18.2.1 with ASME 18.2.2 or ASTM A307 with ASTM A563 or ASTM A194.

2.15 Manual Valves

- .1 Ball valves
 - .1 NPS 2 and under:
 - (a) 600 WOG, two piece brass body, threaded ends
 - (b) stainless steel or chrome plated brass ball,
 - (c) full ported solid ball,
 - (d) PTFE seats and Viton seals
 - (e) pressure rating (flammable liquid): 4100 kPa (600 psig WOG)
 - (f) lockable lever handle with nylon grip,
 - (g) listed to ULC/ORD C842

Standard of Acceptance

 - Conbraco/Apollo fig. 77G-UL (NPS ½ to NPS 1 only)
 - Crane fig F9202
 - Milwaukee fig PM01, or BA-475B
 - Jomar fig T-100NE

- .2 NPS 2½ to NPS 10 – Class 150:

- (a) Class 150 cast steel body, flanged ends, split body design,
- (b) chrome plated carbon steel ball,
- (c) full ported solid ball,
- (d) PTFE seats and seals,
- (e) pressure rating (flammable liquid): 1790 kPa (260 psig) at 93°C (200°F)
- (f) lockable lever handle with nylon grip for NPS 2½,
- (g) gear operator with standard wheel and locking device for NPS 3 – NPS 10
- (h) listed to UL 842

Standard of Acceptance

- Apollo fig 88A-200
- Velan fig SB-150

.3 NPS 2½ to NPS 10 – Class 300:

- (a) Class 300 cast steel body, flanged ends, split body design,
- (b) chrome plated carbon steel ball,
- (c) full ported solid ball,
- (d) PTFE seats and seals,
- (e) pressure rating (flammable liquid): 4680 kPa (680 psig) at 93°C (200°F)
- (f) lockable lever handle with nylon grip for NPS 2½,
- (g) gear operator with standard wheel and locking device for NPS 3 – NPS 10
- (h) listed to UL 842

Standard of Acceptance

- Apollo fig 88A-900
- Velan fig SB-300

.2 Check valves:

.1 NPS 2 and under:

- (a) Class 800 forged steel swing check, steel disc +13% Cr, bolted bonnet, socket weld /threaded ends,
- (b) listed to API 602.

Standard of Acceptance

- Crane B-3675XU-W (socket weld)
- Crane B-3675XU-T (threaded)
- Bonney Forge HL-41-SW (socket weld)
- Bonney Forge HL-41-T (threaded)
- OMB fig. 860

.2 NPS 2½ and larger:

- (a) Class 300 cast steel, steel disc +13% Cr, bolted cover, flanged,

Standard of Acceptance

- Crane 159
- Kitz 300SCOS

2.16 Flexible Hose Connectors for Combustible Liquids

.1 All metal construction flexible connector:

- .1 listed to ULC/ORD C536,

- .2 pipe size NPS 3/4 to NPS 3,
- .3 inner hose: corrugated T304 stainless steel,
- .4 outer jacket: braided T304 stainless steel wire mesh,
- .5 end fitting: NPT with wrench lands, non-swivel type,
- .6 rated working pressure: 1034 kPa (150 psi),
- .7 minimum working pressure: full vacuum,
- .8 maximum working temperature: 66°C (150°F),
- .9 live length: 400 mm (16 in) not including end fittings.

Standard of Acceptance

- Flex-Pression Ltd – UFP series
- OPW Inc – FC series
- Hose Master LLC – FS series

2.17 Truck Fill-hose Connections

- .1 Pressurized fill connection:
 - .1 Cam-and-groove type adaptor, dry-disconnect style with internal spring-loaded poppet valve, and dust cap.
 - .2 tank fill hose attachment: matching coupler with poppet valve handle, and male threaded end.
 - .3 size: as shown.

Standard of Acceptance

- OPW figures 1611AN / 634A / 1711D
- Morrison Brothers figures 927 / 800DC / 928

2.18 Vent Terminals

- .1 Tank normal vent terminal:
 - .1 for continuous pressure and vacuum venting,
 - .2 aluminum body, 40-mesh brass insect screen.
 - .3 pipe size: NPS 2 and 3.

Standard of Acceptance

- OPW series 23
- Morrison Brothers series 354

- .2 Tank emergency vent terminal:
 - .1 normally closed vent, opening on pressure.
 - .2 aluminum body and cast iron lid
 - .3 pressure setting: 7 kPa (16 oz/in²)
 - .4 pipe size: NPS 2 to NPS 10
 - .5 Listed to ULC-S631

Standard of Acceptance

- OPW series 201, 301
- Morrison Brothers series 244O

2.19 Anti-siphon Oil Valve

- .1 Pipe line size, spring loaded, two position angle valve;
 - .1 ULC/ORD-C842 listed,
 - .2 zinc plated cast iron body, machined seats and Buna-N seals,
 - .3 selected for the hydrostatic head measured from the piping on top of tank to fuel pump inlet,
 - .4 fitted with pressure relief trim.

Standard of Acceptance

- EBW (Franklin Fueling) series 600
- OPW 199ASV
- Morrison Brothers series 910

2.20 Pipeline Pressure Relief Valves

- .1 Construction:
 - .1 carbon steel body with carbon or stainless steel internals;
 - .2 Viton o-ring cap seal,
 - .3 pressure rating: minimum 150% of design pressure but not less than 1700 kPa (250 psig),
 - .4 pipe connections:
 - (a) NPS 2 and smaller: threaded NPT
 - (b) NPS 2-1/2 and larger: flanged
- .2 Pressure setpoint:
 - .1 Pump relief: minimum 125% of pump head, but not greater than system design pressure.
 - .2 Other locations: as shown on drawings.

Standard of Acceptance

- Fulflo FVS

2.21 Tank Foot Valves

- .1 Pipe line size, spring loaded, double poppet foot valve
 - .1 bronze body with lapped seats
 - .2 flat poppets
 - .3 20 mesh monel screen

Standard of Acceptance

- Morrison Brothers fig 335A
- Preferred Utilities fig 22
- OPW fig. 92

- .2 Foot valve extractor fitting:
 - .1 NPS 4 tank bung fitting with NPS 1½ or NPS 2 outlet fitting as shown.

- .2 NPS 1-1/2 suction tube.

Standard of Acceptance

- OPW fig. 233E

2.22 Backpressure Regulating Valve

- .1 Sliding gate backpressure regulating valve;
 - .1 carbon steel body with 303T stainless steel internal fittings,
 - .2 internal or external sensing line based on valve size,
 - .3 Buna-N diaphragm,
 - .4 shut-off: ANSI Class IV
 - .5 maximum pressure: 1000 kPa (150 psi)

Standard of Acceptance

- Jordan Valve – Mark 50
- Fisher

2.23 Fusible-link Emergency Shut-Off Valves

- .1 NPS ¾ to NPS 1:
 - .1 fusible link valve for flammable liquid service, stainless steel body with stainless steel trim, threaded ends.
 - .2 spring loaded, held-open actuator with fusible link set to release at 73°C (165°F)
 - .3 Listed to ULC/ORD-C842

Standard of Acceptance

- Morrison Brothers fig. 446

- .2 NPS 1-1/4 to NPS 2:
 - .1 fusible link ball valve for flammable liquid service, carbon steel body with stainless steel trim, PTFE seats, and flanged or threaded ends,
 - .2 spring loaded, held-open actuator, with fusible set to release at 70°C (160°F).
 - .3 FM Class 7440 approved firesafe valve.

Standard of Acceptance

- Metso-Jamesbury - fig 1075
- Essex Fluid Controls - fig THR0001
- Cashco FL series

2.24 Signage

- .1 Signage for shut-off valves for outdoor or underground fuel tanks:
 - .1 2 mm (0.08 in) thick aluminum front and back faces, with polyethylene core sandwich construction.
 - .2 minimum 300 mm x 250 mm (12 in x 10 in), with rounded corners and mounting holes in each corner.

- .3 painted enamel yellow background with black lettering minimum 25 mm (1 in) high.
- .4 Wording (three signs):
 - (a) "EMERGENCY EQUIPMENT DIESEL FUEL SHUT-OFF"
 - (b) "BUILDING SERVICE FUEL SHUT-OFF"
 - (c) "FUEL SHUT-OFF VALVE LOCATED AT FUEL TANK"

2.25 Diesel Fuel-oil Controls

- .1 Provide automatic control devices for the fuel-oil systems including:
 - .1 solenoid valves,
 - .2 motorized valves,
 - .3 tank level measurement devices for aboveground supply tanks.
 - .4 Automatic tank gauges for aboveground main supply tanks
 - .5 oil pressure switches,
 - .6 control signal wiring and power wiring.
- .2 Provide the fuel-oil system automatic control devices as part of a coordinated and integrated fuel-oil control system.
- .3 The fuel-oil controls vendor shall coordinate with the vendor/manufacturer of any fuel storage tank for mounting requirement of instrumentation.
- .4 Submit manufacturer's data sheets for valves, instrumentation and controls with model numbers, performance and design data, outline dimensions and power requirements.
- .5 Submit one completely engineered and coordinated shop drawing package for control wiring between control panels, instrumentation and controlled devices, including control termination wiring to control panels. Partial or incomplete submission of data and/or drawings will be rejected. Submission to include:
 - .1 control panel internal wiring diagrams, showing power, I/O, and communications wiring, and dry-contacts for BAS integration, with full line and terminal numbering,
 - .2 wiring termination drawings for control wiring between control panels (including fuel pump controller panels and auxiliary tank control panels) and instrumentation and controlled devices. Include the quantity, type and size of conductors required and conduit size if not already shown.
 - .3 written Sequence of Operations to cover normal operation and operation under various alarm conditions applicable to that system.
- .6 Product standards:
 - .1 Refer to section 21 11 13 and as follows.
 - .2 CSA C22.2 No. 14 Industrial control equipment
 - .3 CSA C22.2 No. 205 Signal equipment
 - .4 CSA C22.2 No. 61010-1 Safety requirements for electrical equipment for measurement, control, and laboratory use - Part 1: General requirements,
 - .5 CAN/ULC-S661 Overfill protection devices for flammable and combustible liquid storage tanks
 - .6 UL 842 Valves for Flammable Liquids
- .7 Installation and on site testing of fuel oil systems to be performed in accordance with referenced regulations and standards by a specialist firm with an established reputation in this field.

2.26 Solenoid Valves

- .1 Construction:
 - .1 2-way bronze or brass body valve with FKM seals and disc,
 - .2 solenoid operator, 120 VAC with general purpose enclosure,
 - .3 size:
 - (a) NPS ½, Cv = 2.5
 - (b) NPS 1, Cv = 6
 - .4 on-off control,
 - .5 fail position: normally closed,
 - .6 listed to CSA C22.2 No. 139
 - .7 FM approved Class 7400.

Standard of Acceptance

- ASCO fig 8266D085V (NPS ½ only)
- Valcor fig SV84 (NPS 1 only)

2.27 Motorized Control Valves

- .1 Valve body:
 - .1 NPS ½ to NPS 10
 - (a) Class 150 cast steel body, flanged ends, split body design,
 - (b) chrome plated carbon steel ball,
 - (c) full ported solid ball,
 - (d) PTFE seats and seals,
 - (e) pressure rating (flammable liquid): 1000 kPa (150 psig)
 - (f) mounting pad for motorized operator,
 - (g) listed to UL 842 .

Standard of Acceptance

- Apollo fig 88A-200
- Velan fig SB-150

- .2 Electric actuator:
 - .1 internal high-torque electric reversible motor, alloy steel reduction gearing,
 - .2 120 VAC power driven both directions, internal limit switches in each direction of rotation,
 - .3 two accessory end-switches, to prove valve closed and open,
 - .4 de-clutchable manual override operator.
 - .5 valve OPEN-CLOSE position visual indicator
 - .6 CSA Enclosure 4,

Standard of Acceptance

- Emerson Bettis - Torqplus model EM300F

2.28 Level Transmitter/Switch (Type "LTS2")

- .1 Level transmitter/switch:

Issued For Bid and Permit

- .1 RF capacitance type level transmitter, with two programmable relays.
 - .2 Output:
 - (a) 4-20 mA non-isolated, for continuous measurement level,
 - (b) two programmable SPDT relays, narrow differential (alarm) with programmable time delay, rated 3 A at 240 VAC.
 - .3 NEMA 4X enclosure with viewing window,
 - .4 Listed to CSA C22.2 No. 61010-1, for Class 1, Div 1 or 2, Group D,
 - .5 120 VAC, 60 Hz power.
- .2 Tank probe:
- .1 T316 stainless steel and Teflon coated, with integral concentric reference shield, suitable for No. 2 fuel oil in horizontal cylindrical tanks.

Standard of Acceptance

- Arjay Engineering – model 2882W-LT

2.29 Multipoint Level Switch (Type “LS4”)

- .1 Four point float level switch:
 - .1 Magnetic reed switches:
 - (a) SPDT (Form C), hermetically sealed, magnetically activated dry-contact type,
 - (b) electrically insulated to minimum 1.6 kV dielectric breakdown test,
 - (c) switches rated for 0.5A @ 250 V for each switch.
 - .2 T316 stainless steel support shaft,
 - .3 Stainless steel floats with internal magnets,
 - .4 Four factory adjusted control points,
 - .5 NEMA 4X, minimum rating of Class 1, Div 2, Group D,
 - .6 NPS 2 threaded bushing mounting fitting,
 - .7 Listed to CSA C22.2 No. 157 and CAN/ULC S661 as a general use device.

Standard of Acceptance

- Albany Pumps – LEVCON 4
- FPI Sensors – CLIS 4

2.30 Single-point Level Switch (Type “LS1”)

- .1 Vent high level switch:
 - .1 type 304 stainless steel cylindrical float,
 - .2 SPDT reed switch, 100 W at 125 VAC,
 - .3 NPT fitting, for insertion into NPS 4 schedule 10 vent pipe.

Standard of Acceptance

- Magnetrol - model TK1
- Dwyer - Series L6EPB-B-S-3-A

2.31 Tank Overfill Level Alarm System ("OFAS")

.1 General:

- .1 Packaged level sensors and electric overfill alarm panel as a complete certified assembly.
- .2 Control panel and float switch unit listed to CAN/ULC-S661 as a complete system.

Standard of Acceptance

- Albany Pump Co. – APA-FILL with LEVCON float switch
- Ktech Industrial Products Inc. – AL201

.2 Control panel:

- .1 NEMA 4X fiberglass enclosure, with lockable front cover.
- .2 Single level discrete inputs:

Parameter	Percent Tank Volume	Percent Tank Height
High level and stop fill	90%	84%

- .3 Tank level alarm circuit arranged for fail-safe function on event of an open level detection circuit.
- .4 Audible and visual alarm.
- .5 Output high level alarm relay (dry contacts).
- .6 Panel door-front indicating lights:

Lamp Colour	Function
White	Panel energized
Red	Selected tank at 90% fill level

.7 Operating switches:

- (a) momentary test switch for High level light and audible alarm,
- (b) alarm silence switch.

- .8 Permanent label affixed to the panel door, providing operational and pre-fill test instructions to confirm functioning of alarm devices.
- .9 120 VAC, 60 hz power,

.3 Single point float level switch:

.1 Magnetic reed switch:

- (a) SPDT (Form C), hermetically sealed, magnetically activated dry-contact type,
- (b) electrically insulated to minimum 1.6 kV dielectric breakdown test,
- (c) switches rated for 0.5A @ 250 V for each switch.

- .2 T316 stainless steel support shaft,
- .3 Stainless steel floats with internal magnets,
- .4 One factory adjusted control point,
- .5 NEMA 4X, minimum rating of Class 1, Div 2, Group D,
- .6 NPS 2 threaded bushing mounting fitting,

- .7 Listed to CSA C22.2 No. 205 as part of a packaged overflow protection system.

2.32 Water Level Sensor Tanks (Type "LTW")

- .1 Continuous level sensor for detection of oil/water interface in supply tanks:
 - .1 Float type, with 4-20 mA loop powered, continuous measurement output,
 - .2 NEMA 4X enclosure,
 - .3 Stainless steel float stem, with stainless steel floats
 - .4 Float specific gravity to detect for water in fuel oil,
 - .5 Bottom deadband: 25 mm (1 in),
 - .6 Measurement range: 200 mm (8 in),
 - .7 Listed to CSA C22.2 No. 61010-1, for Class 1, Div 1 or 2, Group D,

Standard of Acceptance

- ° FPI Sensors – CLIS series

2.33 Leak Detector – Single Point Switch Type

- .1 Type LDP1:
 - .1 For indoor use.
 - .2 SPST single point float switch,
 - .3 Thermoplastic body and float,
 - .4 Prewired two conductor, PVC insulation wiring lead,
 - .5 Dry-contact float switch rated 10 W, 50-100 VDC.
 - .6 Only to be used where it forms part of a listed industrial control panel.

Standard of Acceptance

- ° Gems fig. LS-10

- .2 Type LDP2:
 - .1 For indoor use.
 - .2 SPST single point magnetic reed switch, reversible NO and NC contact,
 - .3 Hermetically sealed reed switch, in stainless steel body,
 - .4 Prewired two conductor, PVC insulation wiring lead,
 - .5 Dry-contact float switch rated 1.0 A @ 240 VAC,
 - .6 Listed for CSA Class 1, Division 1 and 2, Groups A,B,C,D,T5.

Standard of Acceptance

- ° Albany Pumps fig. Levcon FS-LEAK

- .3 Type LDP3:
 - .1 For outdoor use.
 - .2 SPST single point magnetic reed switch, reversible NO and NC contact, for hydrocarbon detection,
 - .3 SPST switch for conductivity sensor for water detection,

- .4 Stainless steel mesh or perforated screen.
- .5 Prewired three conductor, PVC insulation wiring lead,
- .6 Dry-contact float switch rated 50 W @ 240 VAC,
- .7 Listed for CSA Class 1, Division 1 and 2, Groups A,B,C,D,T5.

Standard of Acceptance

- Albany Pumps fig. Levcon FS-LEAK-OW

2.34 Leak Detection – Continuous Type (LDC1)

.1 Type:

- .1 Continuous hydrocarbon detection sensor cable, for detection of diesel fuel and heating oil,
- .2 Discrete leak detection probe for monitoring of sumps and double wall piping for diesel fuel and heating oil.
- .3 Complete system of sensing elements and control unit listed to CAN/CSA-C22.2 No. 61010-1, and FM Class 7745 approved.

.2 Leak detection sensor cable:

- .1 Coaxial construction, of insulated center 14 AWG copper conductor, hydrocarbon-only permeable core, insulated outer braid conductor, and protective overbraid for mechanical protection,
- .2 Field repairable by trained technicians,
- .3 Sensitive to shallow film of oil – does not require full emersion in oil to sense the presence of oil,
 - (a) insensitive to small areas of oil less than 75 mm (3 in) in diameter (field adjustable)
- .4 Cleanable and reusable when exposed to small quantities of oil
- .5 For detection of diesel fuel and heating oil, while ignoring water,
- .6 Factory or field installed connector kits.

Standard of Acceptance

- Perma-Pipe fig. TFH-Gold

.3 Leak detection probe:

- .1 Single point liquid sensor for diesel fuel and heating oil,
- .2 Sensitive to minimum 6 mm (1/4 in) film of oil – does not require full emersion in oil to sense the presence of oil,
 - (a) insensitive to oil vapour.
- .3 Cleanable and reuseable when exposed to oil,
- .4 For detection of diesel fuel and heating oil, while ignoring water,
- .5 Can be integrated into leak detection cable of the same manufacturer, using a probe integrator unit, including 20 m (60 ft) length of jumper cable and 6 m (20 ft) of sensor cable.

Standard of Acceptance

- Perma-Pipe fig. PHLR

- .4 Control unit:
 - .1 Microprocessor based, single channel alarm unit:
 - (a) capable of monitoring sensor cables, sensor probes, and switch sensors (float or pressure type),
 - (b) a two line x 40 character LCD display, to provide continuous indication of operation, and displays alarm events and leak location,
 - (c) audible and visual alarm indication, with alarm silence and acknowledge input switches,
 - (d) NEMA 12 enclosure.
 - .2 Alarms:
 - (a) stored in non-volatile memory and does not require battery back-up to retain alarm data,
 - (b) stores event location, time and date.
 - .3 Monitor up to 900 m (3000 ft) of cable per channel,
 - .4 Programmed to detect and locate, and to alarm and annunciate:
 - (a) initial leak, growing leak and subsequent multiple leaks on the same sensor cable,
 - (b) breaks and shorts on the cable.
 - .5 Remote alarm relays, 1 Form C (SPDT) each at 120 VAC:
 - (a) no alarm conditions (status)
 - (b) power failure,
 - (c) alarm exists but has not been silenced,
 - (d) alarm exists and has been silenced but not cleared,
 - (e) subsequent alarm detected after prior alarm has been silenced but not cleared.
 - .6 Network communication integration: BACNet/IP gateway, configured for all alarms and leak detection locations.
 - .7 Power: 120 VAC, 60 Hz,

Standard of Acceptance

- Perma-Pipe fig. PAL-AT

2.35 Oil Pressure Switches

- .1 Bourdon tube or spring loaded bellows type

Standard of Acceptance

- Mercoid type DA
- United Electric

2.36 Wiring

- .1 Instrumentation and control wiring:
 - .1 As specified by manufacturer.
- .2 For wiring of ATGS probes, sensors and control panels, use wiring and conduit requirements as specified by ATGS manufacturer installation instructions.

2.37 Engine Exhaust System

- .1 Provide diesel exhaust systems with drip legs, guides, anchors, and expansion joints
- .2 Provide piping for engine crankcase breather vent
- .3 Mufflers:

- .1 Conform to Specification section 26 32 13.
- .4 Exhaust piping materials:
 - .1 Pipe:
 - (a) NPS ½ to NPS 36:
 - ASTM A312 Type 304, schedule 10S welded.
 - .2 Welding fittings:
 - (a) wall thickness to match pipe,
 - (b) butt weld type to ASTM A403
 - (c) socket weld to ASTM B16.11
 - (d) long radius elbows for butt weld
 - .3 Flanges:
 - (a) raised face style
 - (b) stainless steel Type 304, Class 150 to ASTM A182, weld neck or slip-on type, with wall thickness to match pipe.
 - (c) studs and bolts: stainless steel type 316, to ASTM A193
 - (d) nuts: stainless steel type 316, to ASTM A194.
 - .4 ULC/ORD -C959 listed industrial chimneys rated for 760°C (1400°F).
- .5 Expansion joints:
 - .1 Construction:
 - (a) corrugated multi-ply bellows element, type T304 or T321 stainless steel,
 - (b) T304 or T321 stainless steel flow liner,
 - (c) stainless steel flanged connections, fixed or Van Stone, to ANSI 150 Class.
 - (d) size: 150 mm – 600 mm (6 in – 24 in) diameter,
 - (e) shipped with retention bars holding the joint at the non-compressed length.
 - .2 Operating conditions:
 - (a) maximum pressure: 100 kPa (15 psi)
 - (b) maximum temperature: 650°C (1200°F)
 - (c) 3000 cycles for any one movement to EMJA standard.
 - .3 Designed to absorb:
 - (a) axial compression: 75 mm (3 in) minimum,
 - (b) axial expansion: 13 mm (½ in) minimum,
 - (c) lateral offset: 15 mm (½ in) minimum.
 - (d) axial spring rate: 14 N/m (125 lb/in) maximum
- .6 Ventilation Roof Thimbles
 - .1 ULC/ORD -C959 listed roof thimbles for industrial chimneys.
- .7 Termination:
 - .1 Terminate vertical diesel exhaust stack min. 600 mm above the roof of the enclosure
 - .2 Provide rain cap.
- .8 Drain Line
 - .1 Provide a drip leg same size as exhaust up to NPS 6 and NPS 6 for larger sizes;
 - (a) located between the engine exhaust muffler and the base of the vertical exhaust stack, and
 - (b) fabricated from Schedule 80 pipe for carbon steel exhaust systems, or schedule 10 stainless steel for stainless steel systems,

- (c) minimum 200 mm (8 in long) before reducing to drain line size.
- .2 For horizontal exhaust stacks, pitch the exhaust stack to drain to outdoors.
- .3 Provide a NPS 1 drain line and run the drain line down to within 450 mm (18 in) of floor and terminate with valve and female hose end connector.
- .9 Exhaust Stack Support and Vibration Control
 - .1 Locate first anchor at engine end of the muffler. Provide additional expansion joints and anchors as follows:
 - (a) at the exhaust outlet of the muffler/silencer and as shown,
 - (b) anchors consisting of structural steel angles, channels, or plates fastened to structure, at locations as shown.
 - (c) provide a roller hanger support within 300 mm (12 in) of each side of an expansion joint.
 - .2 Provide seismic restraint of muffler and exhaust stack
- .10 Min. Clearance
 - .1 Maintain the following minimum clearance dimensions:
 - (a) horizontal clearance from exhaust stack to combustibles: 225 mm (9 in) unless otherwise shown,
 - (b) vertical clearance from exhaust stack to combustibles: 225 mm (9 in) unless otherwise shown,
 - (c) clearance between thimble and combustible materials: 25 mm (1 in) unless otherwise shown.
 - (d) ventilation space dimension from exhaust stack to thimble:

Stack insulation thickness mm (in)	Clearance mm (in)
0 (0)	200 (8)
25 (1)	150 (6)
50 (2)	100 (4)
75 (3) and larger	50 (2)

2.38 Combustion and Ventilation Air Control System

- .1 Ventilation, exhaust and recirculation dampers to be sized to result in the aggregate of ventilation air and recirculated air flow rates to be constant within +/- 15% of design peak flow rate across all mixing ratios between 0 and 100% ventilation flow rate.
- .2 Combustion air damper:
 - .1 two-position, insulated extruded aluminum parallel blade damper,
 - .2 maximum core (face) velocity: 2.0 m/s (400 fpm),
 - .3 higher air intake velocities are permitted where manufacturer can demonstrate the correct functionality of the unit at resulting higher static pressure and where approved by the AHJ for fuel safety,
 - .4 electrically operated, fail-open, with damper to open fully under spring action \leq 30 seconds,
 - .5 sized to meet combustion air requirements for the engine.
- .3 Ventilation air damper:

- .1 modulating, insulated, extruded aluminum opposed blade damper,
- .2 maximum core (face) velocity: 2.0 m/s (400 fpm)
- .3 higher air intake velocities are permitted where manufacturer can demonstrate the correct functionality of the unit at resulting higher static pressure and where approved by the AHJ for fuel safety,
- .4 electrically operated, fail-open,
- .5 sized to meet engine radiator ventilation air requirements.
- .4 Exhaust air damper:
 - .1 modulating, insulated extruded aluminum opposed blade damper,
 - .2 maximum core (face) velocity:
 - (a) 7.5 m/s (1500 fpm) where damper discharging into an exhaust plenum that separates the exhaust damper from the exhaust air louvre, or
 - (b) 2.5 m/s (500 fpm) where damper is placed immediately upstream of the exhaust air louvre,
 - .3 electrically operated, fail-open,
 - .4 sized to meet engine radiator ventilation air requirements.
- .5 Recirculation air damper:
 - .1 modulating, insulated extruded aluminum parallel blade damper,
 - .2 maximum core (face) velocity: 7.5 m/s (1500 fpm)
 - .3 electrically operated, fail-close,
 - .4 sized to match ventilation airflow rates.
- .6 Actuator:
 - .1 120 Volt electric actuator with spring return, stroking damper from closed to open with 4 -20 mA signal
- .7 Instrumentation and control:
 - .1 RTD type space temperature sensor with digital display,
 - .2 located within 200 mm (8 in) to air entering the radiator.
 - .3 Interconnected to facility BAS for monitoring and alarm.
- .8 Sequence of operation:
 - .1 On power failure or when engine is commanded to start (in normal run mode and test mode), the combustion air damper fails open and remains open. Ventilation damper may remain closed for an initial time period not exceeding 30 seconds.
 - .2 Space temperature sensor modulates the ventilation air damper, recirculation air damper, and exhaust air damper operates as an air-economizer cycle to maintain space temperature setpoint (adjustable; default = 20°C.
 - .3 When engine shuts-down, combustion air damper closes. Ventilation damper and exhaust dampers remain open until space temperature sensor decreases below 18°C or 30 minutes (adjustable) has expired, whichever comes first.

2.39 Acoustic Treatment

- .1 Silencers
 - .1 Factory manufactured of galvanized or prime painted steel, meeting SMACNA material standards.

.2 Construction:

- (a) 0.8 mm (22 ga) minimum outer shell with airtight mastic filled seams for rectangular low velocity applications up to 10 m/s (2000 fpm),
- (b) 1.6 mm (16 ga) welded outer shell for rectangular high velocity application over 10 m/s (2000 fpm) and for circular units 600 mm (24 in) diameter and larger,
- (c) 1.2 mm (18 ga) welded outer shell for circular units of less than 600 mm (24 in) diameter,
- (d) 50 mm (2 in) slip connections, and lifting lugs, and
- (e) inner casing minimum 0.8 mm (22 ga) perforated metal, enclosing acoustic media,
- (f) acoustic media
 - acoustic quality, glass fibre, free of shot and odour bacteria and fungus resistant.
 - free of corrosion causing or accelerating agents.
 - minimum density of 72 kg/m³ (4.5 lb/ft³) when packed under 10% compression.
 - in accordance with Fire Code requirements for duct lining.
 - erosion protection by Tedlar covering between media and perforated metal.
 -

.3 Performance

- (a) Pressure drop: maximum pressure drop with system effect less than 35 Pa (0.14 inwg), higher pressure drop is permitted where manufacturer can demonstrate the correct functionality of the unit at resulting higher static pressure and where approved by the AHJ for fuel safety
- (b) Insertion loss at each octave band with system effect: to meet overall enclosure acoustic rating.

.4 Drain Pan

- (a) Provide drain pan with drain at the bottom for silencer installation with water penetration,
- (b) Slope the bottom of the silencer and drain pan to the drain connecting to the outside

.2 Enclosure Overall Acoustic Rating

.1 53 dBA at 7 m Enclosure

2.40 Heating System

.1 Cabinet Unit Heaters

.1 Capacity and Quantity

- (a) To be sized to maintain space temperature of 10°C (58°F) when the engine is not running.

.2 Casings:

- (a) surface mounted, recessed or semi-recessed type
- (b) 1.6 mm (16 ga) steel finished with factory applied baked primer with internal glass fibre insulation,
- (c) integral air outlet and inlet grilles,
- (d) removable access panels allowing service of fans, coils, isolating valves and controls.
- (e) removable 25 mm (1 in) fibrous glass media replaceable filters.

.3 Coils:

- (a) electric coils of nickel-chrome electric resistance wire embedded in magnesium oxide and enclosed in stainless steel sheathing with low watt density extended fins.
- (b) heating elements and fan controlled by two stage line voltage thermostat for remote mounting, with enclosure to suit class and group of application,
- (c) arranged for two stage heating with magnetic contactors, high temperature limit switch, fan override switch, and single phase motor starting switch mounted as shown,

.4 Fans:

- (a) statically and dynamically balanced, double width centrifugal fans with sleeve bearings, direct connected to resiliently mounted single phase totally enclosed motor.

- .5 Support and Connection
 - (a) Attach heaters to the enclosure structure with angles, hanger rods and supplementary suspension steel.
 - (b) Install fused disconnect, remote thermostats, multi-speed controllers, motor starter switches and other controls as shown to suit class and group of application and provide interconnecting wiring
- .2 Instrumentation and control:
 - .1 space-type Line-voltage thermostat.
- .3 Sequence of Operation:
 - .1 space thermostat cycles unit heater On/Off to maintain a space temperature of 10°C (58°F) when the engine is not running.

2.41 Ventilation Fan System

- .1 Fans:
 - .1 Provide exhaust fan to maintain interior space temperature when generator is not in operation.
 - .2 labelled with Air Performance, or Sound and Air Performance AMCA Certified Rating Seals
 - .3 .Mount fans with vibration isolation, restraining snubbers, flexible electrical leads, and flexible connections to inlet and discharge ductwork.
- .2 Instrumentation and control:
 - .1 same space temperature sensor as used for damper control.
- .3 Sequence of operation:
 - .1 when the generator is not running, on rise in space temperature above setpoint (adjustable, default = 30°C), ventilation damper Opens and exhaust fan Starts.

2.42 Vibration Isolation of Mechanical Equipment

- .1 Provide vibration isolation for mechanical equipment as follows:
 - .1 fans:
 - (a) Type A base with Type 3 isolator, min. deflection of 12.7mm (0.5 in.)
 - .2 fuel piping:
 - (a) spring mounts or spring hangers with static deflection of twice deflection of isolated equipment at first point of support and
 - (b) 25 mm (1 in) minimum static deflection at remaining supports.
 - .3 Pumps
 - (a) for installation of floor: Type B base with type 2 isolator, min. deflection of 6 mm (0.25 in.)
 - (b) for elevated installation: Type C base with type 3 isolator, min. deflection of 19 mm (0.75 in.)
 - .4 unit heaters:
 - (a) Type A base with Type 3 isolator, min. deflection of 12.7mm (0.5 in.)

2.43 Factory DDC Control System

- .1 Provide factory installed, wired and programmed Direct Digital Control (DDC) system, including instrumentation, to provide control of ventilation dampers and fans and to provide other supervisory and control functions.
- .2 DDC controllers to be BACnet MSTP or BACNet/IP devices.
- .3 Mount DDC controllers in an electrical enclosure, complete with all necessary power supplies.
- .4 Provide wiring and conduit for power, instrumentation and communication wiring. Use flexible watertight conduit for the final 300 mm (12 in) length at connections to instrumentation, dampers, and rotating equipment.
- .5 Provide an empty 40 mm (1 ½") conduit from the DDC control panel to a recessed junction box at the shore services termination location, for connection to the building BMS system.

2.44 Fire Protection System

- .1 Allocate space for fire protection equipment that is readily accessible adjacent to an access door, and arrange piping to allow immediate access to system shut-off device upon immediate entry to the enclosure.
- .2 Fire protection system is to be integrated with facility's existing fire alarm system.
- .3 Provide multipurpose dry chemical extinguishers as required

2.45 Access Stairs/Platforms

- .1 Factory fabricated, field-installed access stairs and service platform where door sill elevation is more than 200 mm (8 in) above local exterior grade or work platform level.
- .2 Service platform:
 - .1 galvanized steel, with subway grating or similar anti-slip perforated surface,
 - .2 designed for 2.4 kN/m² (50 lb/sf) live load or 890 N (200 lbf) concentrated load.
 - .3 sized to allow full door opening swing with a person standing to the side of the door.
- .3 Stairs:
 - .1 galvanized steel rails and treads, with subway grating or similar anti-slip perforated surface for treads, and at least 550 mm (22 in) clear width,
 - (a) stair run: 255 to 355 mm (10 to 14 in) deep,
 - (b) stair rise: 125 to 180 mm (5 to 7 in) high.
 - .2 closed side rails, open risers,
 - .3 designed for 2.4 kN/m² (50 lb/sf) live load,
- .4 Handrails:
 - .1 provide handrails around service platforms and on both sides of stairs where service platform is more than 450 mm (18 in.) above local exterior grade or work platform level,
 - .2 minimum Ø32 mm (1-1/4 in. dia) or square section, galvanized steel pipe for posts and handrails, and galvanized steel plate for toe kicks,
 - .3 design load: withstand a horizontal load applied outward of not less than 1.1 kN (250 lbs) applied at any point,
 - .4 handrail guards to meet the following requirements except where the applicable health and safety legislation at the place of the Work has more restrictive requirements;
 - (a) top handrail height of between 1000 and 1050 mm (40 to 42 in) above the local work surface,

- (b) mid-rail height of approximately 500 mm (20 in) above the local work surface,
- (c) post spacing not to exceed 550 mm (22 in),
- (d) 125 mm (5 in) high toe kick plate.

3 EXECUTION

3.1 Installation

- .1 Place enclosure unit on structural supports, shim level, anchor base frame.
- .2 For installations on a roof curb, providing counter-flashing between the enclosure unit base and the roof curb.
- .3 Provide and connect shore services as shown and in accordance with applicable Specification sections.

3.2 Cleaning

- .1 Prior to starting the generator for the first time, thoroughly clean inside of enclosure of loose debris and packaging materials, and clean all surfaces by vacuuming.

3.3 Start-Up and Testing

- .1 Start-up and test generators in accordance with Specification section 26 32 13.
- .2 Test diesel fuel systems in accordance the Specification section 23 11 13, and section 23 13 23.
- .3 Test enclosure ventilation system to verify control sequence of operation under as-tested ambient site conditions. Maintain a record of outdoor air temperature during test. Where the testing requirements for the generator require additional tests at other outdoor conditions, test the ventilation system under those conditions as well.

3.4 Acoustic (Noise) Testing

- .1 Conduct noise testing of engine(s) at maximum rated capacity in accordance with the requirements of the local municipality, but not less than as stated in Specification section 26 32 13 and as follows:
- .2 Take noise measurements in the following locations:
 - (a) at 1m (3 ft) from and centered on each exterior face of the enclosure,
 - (b) within 3 m (10 ft) of the roof edge (for rooftop installations)
 - (c) at the property line.
- .3 Record straight-line distances between points of measurement and the closest external face of the unit enclosure.
- .4 Take noise measurements of the background noise condition with the generators not operating over a one hour averaged time period at 12 noon and either 07:00 hrs or 23:00 hours.
- .5 Take two sets of measurements while the generator(s) are operating at their maximum rated capacity:
 - (a) first set: between 07:00 and 23:00 hrs
 - (b) second set: between 23:00 and 07:00 hrs.
- .6 Make noise levels readings on the dBA weighting scale over eight bandwidths.
- .7 Report results in tabular and graphical plots, including distances between source and test receptors.
- .8 Report any objectionable noise and be prepared to locate cause by instrumentation and analysis.

3.5 Manufacturers' Service Representation on Site

- .1 Generator manufacturer to supply factory trained service representative to provide field services in accordance with Specification section 26 32 13.

- .2 Submit copies of completed manufacturer start-up and test records to Contractor and Consultant prior to hand-over of equipment.

3.6 Site Acceptance Testing

- .1 Conduct Site Acceptance Testing (SAT) of the generator(s) in accordance with Specification section 26 32 13 and in the presence of and to the satisfaction of the Owner's representative(s).

3.7 Commissioning Program

- .1 In addition to the manufacturer Site Acceptance Testing, installation contractor and manufacturer to provide field service personnel to participate in the system integration commissioning of the equipment and/or system including:
 - .1 review of equipment and system commissioning procedures provided by Owner in addition to the manufacturers own testing procedures,
 - .2 to have control of and operation of equipment during testing,
 - .3 adjusting of equipment controls as required to simulate load and/or fault conditions, and
 - .4 assist with record keeping of test results.

3.8 Demonstration and Training

- .1 Demonstrate the operation of, and providing training on, the system in accordance with section 01 79 00.

3.9 Test and installation records

- .1 Provide an installation record for the following elements of the work and submit the original to the Owner and a copy to the Engineer. Provide an additional copy when required or requested by the Authority-having-Jurisdiction.
 - .1 equipment start-up and testing reports,
 - .2 noise testing reports,
 - .3 test reports or inspection reports from applicable AHJ's.
 - .4 test reports required by other Specification sections referenced herein.

End of Section

TRANSFER SWITCHES

26 36 23

1 GENERAL

1.1 Scope

- .1 Provide transfer switches as shown.

1.2 Related Sections

- .1 Without limiting the scope of work or applicability of other specification sections, the work under this section directly integrates with or refers to the following specification sections:
 - .1 26 05 48 Vibration Isolation
 - .2 26 05 49 Seismic Restraints.
 - .3 26 08 05 System Co-ordination, Verification & Testing.
 - .4 26 32 13 Power Generation Diesel

1.3 Applicable Codes and Standards

- .1 Installation codes and standards:
 - .1 ANSI/NETA ATS Standard for Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems.
 - .2 CSA C282 Emergency Electrical Power Supply for Buildings,
 - .3 CSA Z32 Electrical Safety and Essential Electrical Systems in Health Care Facilities.
- .2 Product Standards:
 - .1 CSA C22.2 No. 94.1 Enclosures for Electrical Equipment, Nonenvironmental Considerations
 - .2 CSA C22.2 No. 94.2 Enclosures for Electrical Equipment, Environmental Considerations
 - .3 CSA C22 No. 178.1 Transfer Switch Equipment,
 - .4 NEMA ICS 10 AC Automatic Transfer Switches.

1.4 Manufacturer Services

- .1 Additional services are to be provided by the equipment supplier or their field service representatives and costs for this work are to be included in the Bid Amount.
- .2 Equipment manufacturer, or their supplier or field service representatives to provide the following services and associated service equipment:
 - .1 interface control wiring diagrams, schedules and wire running lists between all components,
 - .2 factory testing and supplementary acceptance testing,
 - .3 provision of information as appropriate to install and test the equipment,
 - .4 technical supervision of equipment unloading, equipment site assembly, installation of power and control cables, cable connections, and all other work normal to the electrical trade,
 - .5 on site setup of timers and controls,
 - .6 on site programming of controls and communications equipment,
 - .7 on site testing,
 - .8 technical assistance during acceptance testing,
 - .9 technical assistance during commissioning,

- .10 factory and field training of the Owner's staff in the complete operation of the system,
- .11 warranty service on a priority basis,
- .12 data book including schematic diagrams,
- .13 check out of system one month prior to expiry of warranty period,
- .14 services of a technical representative as required by the Owner to review production schedules, delivery dates, shop drawing changes, shipping details, shop and field testing and training programs.

1.5 Submittals

- .1 Shop drawings submittals:
 - .1 Product data sheets for materials specified herein.
- .2 Provide one additional set of drawings shipped with the equipment for start up use.
- .3 Operating and maintenance data:
 - .1 Installation, operating, and maintenance data and instructions to cover the equipment furnished.
 - .2 Technical data:
 - (a) schematic diagram of components, controls and relays,
 - (b) illustrated parts lists with parts catalogue numbers,
 - (c) certified copy of factory test results.
 - .3 Complete spare parts list, including parts location diagrams or drawings.
 - .4 List of priced spare parts which manufacturer recommends to be on hand during start-up and during the first two year's operation.
 - .5 A material list, listing the quantity, rating, type, and manufacturer's catalog number of all equipment on each unit.

1.6 Quality Control

- .1 Manufacturer's Production Test and Records:
 - .1 Submit certified copies of reports of manufacturer's production testing for all transfer switches.
- .2 Factory Acceptance Testing (FAT):
 - .1 Refer to Part 2 Product for requirements.
- .3 Site Acceptance Testing:
 - .1 Refer to Part 3 Execution for requirements.

1.7 Warranty

- .1 In addition to the warranty provisions of Division 01, provide a written warranty for parts, labour and services to repair or replace any part of the equipment within a period of two (2) years from date of acceptance by the Owner, against:
 - .1 faulty or inadequate design, manufacture or operation,
 - .2 defective material or workmanship, or both,
 - .3 breakage or other failure that occurs under normal and proper operation of the equipment.
- .2 Manufacturer to correct deficiencies which occur during the two year warranty period at no additional cost to the Owner. The manufacturer's technical representative to call back within one (1) hour and be available on site on a priority basis i.e. within 4 hours of being notified of a deficiency requiring repair.

2 PRODUCTS

2.1 General

- .1 Transfer switches to be provided by one manufacturer.

Standard of Acceptance

- ASCO Power Technologies 7000 series
- Russelectric
- GE
- Eaton
- Cummins
- Caterpillar

2.2 General Features

- .1 Type A without any internal trip devices.
- .2 Suitable for use as part of a code required emergency power system.
- .3 Electrically operated, mechanically held contacts.
- .4 Designed for unattended operation.
- .5 Double throw type:
 - .1 3 pole plus solid neutral for 120/208V switches.
- .6 Rated for operation on the system shown, either:
 - .1 600V 3 phase, 3 wire high resistance grounded,
 - .2 600V 3 phase, 3 wire solidly grounded,
 - .3 600/347V 3 phase, 4 wire solidly grounded, or
 - .4 120/208V 3 phase, 4 wire solidly grounded, as applicable.
- .7 Suitable for operation on a high resistance grounded system without requiring a neutral connection and without introducing any load current into the ground connection.
- .8 Main contacts:
 - .1 protected by separate arcing contacts and arc chutes,
 - .2 interlocked mechanically and electrically.
- .9 Sensing and control relays:
 - .1 continuous duty,
 - .2 industrial control quality.
- .10 Pilot lights:
 - .1 LED type,
 - .2 with "Push to Test" feature.
- .11 Cable lugs:
 - .1 suitable for copper conductors,
 - .2 suitable for the cable sizes shown,
 - .3 oversized where required to suit feeders that have been oversized (eg: to meet voltage drop criteria),

- .4 reduced sizes where required to suit feeders that are substantially smaller than the transfer switch rating (eg: due to switch oversizing to meet the specified withstand ratings).
- .12 Switch lifting yoke.
- .13 Seismically certified to withstand the ground acceleration criteria and seismic demand requirements for non-structural equipment as specified in the Building Code for the geographic location of the installation.

2.3 Automatic Transfer Switches (ATS)

- .1 Basic operation of each ATS:
 - .1 when any phase of the preferred source power at the transfer switch drops below 90% of preferred source voltage for the selected time, a relay on that transfer switch to operate to cause the Diesel engine to be started,
 - .2 when Diesel-alternator reaches rated voltage and frequency, the transfer switch to operate to transfer load to Diesel-alternator,
 - .3 when preferred source power supply is restored and voltage on all phases is 90% or more for the selected time, switch to transfer load back to preferred source power supply,
 - .4 after a preselected time delay the engine start signal is removed.
- .2 Automatic transfer switches shown connected to continuously energized preferred and alternative sources:
 - .1 controls to prevent transfer to the alternative source unless:
 - (a) the normal source fails or,
 - (b) the test switch on the respective unit has been operated.
 - .2 Selector switch to allow selection of the preferred source.
 - .3 Engine start contacts not required.
- .3 Provide in each automatic transfer switch, as indicated by "ATS" in the name, the following features:
 - .1 a microprocessor-based control panel with field accessible adjustments to such items as voltage pick-up and drop-out and timing controls,
 - .2 three phase true RMS over and under voltage sensing of both the preferred and alternative sources with programmable set points,
 - .3 over and under frequency sensing of both the preferred and alternative sources with programmable set points,
 - .4 engine start contacts,
 - .5 duplicate engine start contacts,
 - .6 time delays:
 - (a) on engine start after preferred source fails, adjustable from .5 to 6 seconds, set at 2 seconds,
 - (b) on transfer to alternative source, adjustable 0-300 seconds, set as indicated,
 - (c) on alternative source failure, adjustable from .5 to 6 seconds, set at 6 seconds,
 - (d) on transfer to preferred source after restoration of preferred source, adjustable 0-30 minutes, set as indicated,
 - (e) on transfer to preferred source following a test of the alternative source, adjustable 0-30 minutes, set at 30 seconds,
 - (f) on unloaded engine cool down, adjustable 0-60 minutes, set at 0 minutes,
 - .7 selector switches, mounted on outside of door with a guard to prevent accidental actuation:

- (a) maintained contact type test switch:
 - i) to simulate a power failure and cause Diesel-generators to start and load to transfer,
 - ii) to cause the transfer switch to transfer back to the preferred source, following the time delay, after the test switch is manually reset,
 - (b) four position selector switch for engine control. Auto / Off / Engine Test / System Test,
 - (c) reset switch for manual retransfer to preferred source with bypass of time delay,
 - (d) switch and circuitry to enable selection of the alternative source as the preferred source with override in event of failure of the alternative source,
 - (e) engine disconnect switch: two position maintained contact switch to inhibit the engine start signal from being sent when maintaining the ATS,
- .8 pilot lights:
- (a) to indicate transfer switch is in preferred source position,
 - (b) to indicate transfer switch is in alternative source position,
 - (c) to indicate preferred source power is available,
 - (d) to indicate alternative source is available,
- .9 auxiliary contacts:
- (a) contact to close when preferred source fails,
 - (b) four on main shaft, closed when on preferred source,
 - (c) four on main shaft, closed when on alternative source,
- .10 remote test circuitry,
- .11 terminal provisions for a remote customer contact to inhibit transfer to the preferred source,
- .12 terminal provisions for a remote customer contact to inhibit transfer to the alternative source,
- .13 externally-mounted quick-make quick-break operating handle on switches ≥ 600 Ampere rating,
- .14 electrical metering of the load side of the transfer switch, metering to be true RMS, 1% accuracy and to include the following:
- (a) Voltages, 3 L-L
 - (b) Frequency
 - (c) Current, 3 phases
 - (d) %unbalance, Voltage and Current
 - (e) kW
 - (f) kVA
 - (g) kVAR
 - (h) power factor
 - (i) kWh
- .15 ModBus Ethernet communications system to provide the following:
- (a) transmission of the load side metering data to the building management system and to the generator control switchboard, including:
 - i) Voltages, 3 L-L
 - ii) Frequency
 - iii) Current, 3 phases
 - iv) %unbalance, Voltage and Current
 - v) kW
 - vi) kVA

- vii) kVAR
- viii) power factor
- ix) kWh
- (b) transmission of status conditions to the building management system and to the generator control switchboard, including:
 - i) Loss of preferred source
 - ii) Preferred source available
 - iii) Alternative source available
 - iv) TS connected to preferred source
 - v) TS connected to alternative source
 - vi) TS parked in neutral position (where applicable)
 - vii) TS in bypass (where applicable)
 - viii) TS under load management control (where applicable)
 - ix) TS transfer inhibit by SUPS (where applicable)

2.4 Additional Features for Selected Automatic Transfer Switches

- .1 For switches with bypass/isolation feature:
 - .1 built-in two way manual bypass/isolation system,
 - .2 to allow the active switch element to be removed from the system while the load remains energized from either the preferred source or the alternative source,
 - .3 bypass/isolation switch ratings: same as the active switch,
 - .4 load break and load make contacts,
 - .5 externally-mounted quick-make quick-break operating handle,
 - .6 safe operation as a manual transfer switch,
 - .7 auxiliary contacts to indicate when the transfer switch is in bypass mode,
 - .8 automatic shutters which close when the active element is withdrawn, to provide isolation from live bus.
- .2 For switches that supply elevator equipment:
 - .1 two selective load disconnect control contacts,
 - .2 contacts to operate prior to and/or after load transfer and retransfer (elevator pretransfer signal),
 - .3 contacts adjustable from 0 to 300 seconds, set at 20 seconds,
 - .4 engine start contacts not required.
- .3 For switches that supply SUPS equipment:
 - .1 transfer inhibit circuit to prevent a transfer in either direction upon closure of a remote contact,
 - .2 transfer to occur should the source, to which the ATS is connected, fail, regardless of the status of the remote contact.
- .4 Provide the additional features as indicated by a **v** mark in the following table:

Transfer Switch Name	Bypass/Isolation Feature	Switch Supplies Elevator Equipment	Switch Supplies SUPS Equipment
ATS-1	✓	✓	✓
ATS-2	✓	✓	✓

2.5 Open Transition Transfer Switches

- .1 To provide a break before make switching operation in each direction.
- .2 Preferred source and alternative source contacts mounted to a common shaft.
- .3 Single operator to provide a high speed switching operation with no intentional delay in a neutral position.
- .4 In phase monitor:
 - .1 to operate in both directions,
 - .2 to inhibit a transfer between live sources until the phase angle between the sources is at the selected angle and is decreasing,
 - .3 phase angle transfer initiation point to be adjustable from 5° to 60°.
 - .4 factory set the phase angle at 15° except where indicated otherwise,
 - .5 reset the phase angle on site to suit the characteristics of the load,
 - .6 to permit transfer when both sources are synchronized and in phase,
 - .7 to permit transfer when one source is not energized.

2.6 Automatic Transfer Switch Table

- .1 Provide automatic transfer switches of the type indicated by the ✓ mark in the following table:

Transfer Switch Name	Open Transition	Delayed Transition	Closed Transition	Solid State Transition
ATS-1	✓			
ATS-2	✓			

2.7 Ratings

- .1 Continuous duty at capacity specified without derating.
- .2 Capable of withstanding fault currents of magnitudes \geq than the values shown, for the durations shown.
- .3 Capable of functioning in the normal manner:
 - .1 following a fault, up to the maximum level and duration specified for the withstand rating of the switch,
 - .2 after closing into a fault of a magnitude not less than that specified for the withstand rating of the switch.
- .4 The specified withstand ratings to be achieved without requiring the operation of a breaker or a fuse to protect the switch, except where shown otherwise.
- .5 Provide transfer switches as shown and in accordance with the following table:

Transfer Switch Name	Continuous Current Rating (Amperes)	30 Cycle Withstand and Closing Rating (Amperes, RMS Symmetrical @ 600V)	3 Cycle Withstand and Closing Rating (Amperes, RMS Symmetrical @ 600V)
ATS-1	1600	42KAIC	42KAIC
ATS-2	800	36KAIC	36KAIC

2.8 Settings

- .1 Factory set the TS's in accordance with the settings listed in the following table. Confirm settings prior to manufacture and reprogram on site as directed.

Transfer Switch Name	Time Delay on Transfer to the Alternative Source (seconds)	Time Delay in the Neutral Position (seconds)	Time Delay on Transfer to the Preferred Source (Seconds)
ATS-1	0	0.5	300
ATS-2	0	0.5	300

2.9 Enclosure

- .1 Enclosure:
- .1 Listed to CSA C22. 2 NO. 94.1 or 94.2 as applicable, Type 1 with drip shield except where indicated otherwise,
 - .2 suitable for installation in a sprinklered room,
 - .3 sized to accommodate the cable/bus duct feeders shown,
 - .4 doors:
 - (a) to be hinged,
 - (b) to open not less than 135°,
 - (c) equipped with a T-Handle 3 point locking system complete with lock and latch,
 - .5 instrumentation and status lights to be visible without opening doors,
 - .6 for transfer switches requiring rear access, provide three infra-red viewing ports supplied loose for field installation.
- .2 Finish:
- .1 rust-inhibiting metal treatment process,
 - .2 powder coat finish to UL50 3R,
 - .3 colour: ANSI #49 grey
- .3 Provide 2 pressurized spray cans of matching paint to touch-up small areas marred during installation.

2.10 Equipment Identification

- .1 Provide equipment identification in accordance with Section 26 05 01 - Electrical General Requirements.
- .2 Provide a nameplate on each TS. Nameplates to be 3 mm (c") thick, with white lettering on a red background, with bevelled edges.

- .3 Lettering to be engraved and to be 5 mm ($\frac{1}{4}$ ") high, except where indicated otherwise.
- .4 Confirm wording on nameplates prior to manufacture.
- .5 Nameplates to indicate:
 - .1 Name of the switch, eg: ATS-1 (8 mm ($\frac{1}{4}$ ") high lettering)
 - .2 System voltage, eg: 120/208V, 3Ø, 34W
 - .3 Switch current rating, eg: 1600 A
 - .4 Preferred source, eg: PREFERRED SOURCE: MAIN SWBD
 - .5 Alternative source, eg: ALTERNATIVE SOURCE: GEN 2
 - .6 Load supplied, eg: SUPPLYING: SWBD-EEA
- .6 Mechanically attach nameplates with stainless steel screws.

2.11 Factory Acceptance Testing (FAT)

- .1 Provide FAT on transfer switches rated ≥ 600 Amperes.
- .2 FAT:
 - (a) to be in addition to manufacturer's standard post-production tests,
 - (b) to be witnessed by the Independent Testing Organization,
 - (c) may be witnessed by the Consultant, provide the Consultant with at least one week's notice of the FAT schedule and accommodate the Consultant's presence at the factory throughout the FAT.
- .3 As part of the FAT, perform the following inspections and tests on each switch:
 - (a) physical inspection,
 - (b) compliance with specifications,
 - (c) proper operation of all control and interlocking systems,
 - (d) dynamic transfer between two sources,
 - (e) per the NETA Acceptance Testing Specification for Electrical Power Distribution Equipment and Systems, Section 7, #7.22.3 Emergency Systems, Automatic Transfer Switches: however, testing of "field" connections is not required,
 - (f) for closed transition transfer switches include:
 - i) waveform capture to demonstrate seamless transfer of load within 100ms,
 - ii) demonstration of protection circuitry to prevent paralleling of sources beyond 100ms,
 - iii) testing of the switch in delayed transition mode,
 - (g) for solid state transition transfer switches include:
 - i) waveform capture to demonstrate open transfer of load within specified outage duration with a load of not less than xxxkW,
 - ii) demonstration of SCR gate test board,
 - iii) demonstration of shorted SCR detection system,
 - iv) demonstration of the static switch disable switch,
- .4 Submit certified copies of the FAT reports.
- .5 Correct deficiencies prior to shipment.

2.12 Manufacturers' Service Representation on Site

- .1 Refer to Part 3 Execution for requirements.

3 EXECUTION

3.1 Installation

- .1 Install switches in accordance with the manufacturer's instructions.
- .2 Provide, under this division, a 100mm (4") reinforced concrete pad with beveled edges for each floor mounted transfer switch. Seal with paint or concrete sealer to prevent concrete dust from entering equipment.
- .3 Anchor the concrete pad to the building structure in accordance with Section 26 05 48, Vibration Isolation and Seismic Restraints.
- .4 Receive equipment at site and inspect for damage.
- .5 Provide necessary cranes and miscellaneous equipment to unload and transfer equipment into its final location.
- .6 Position transfer switches to provide:
 - .1 adequate clearance at the front, with draw-out elements in the drawn-out position,
 - .2 adequate clearance at the rear for switches requiring rear access.
- .7 Secure transfer switches to the concrete pad and/or the building structure.
- .8 Provide interconnecting, incoming and outgoing cable, bus duct, and control wiring connections as shown and as required.
- .9 Terminate power cables with two hole long barrel compression connectors equal to Burndy YA-2N.
- .10 Provide bonding of each transfer switch to perimeter ground bus with a #4/O green insulated copper conductor in PVC conduit. Terminate with Burndy YA-2N lugs.
- .11 For each transfer switch requiring rear access, install the three infra-red viewing ports supplied loose, and locate to allow for unobstructed scanning of the power connections.
- .12 For switches equipped with a quick make quick break operator attach a lamicoid warning label adjacent to the operator, with white lettering on a red background, stating "DO NOT OPERATE WITH SWITCH ENERGIZED".
- .13 For Closed Transition Transfer Switches include:
 - .1 signs warning of closed transition transfer use, to the satisfaction of the local utility in the following locations:
 - (a) doors to main high voltage room,
 - (b) each main high voltage disconnect switch,
 - (c) each closed transition switch.
 - .2 2 #12 in EMT to the normal power breaker feeding the switch, connect to trip the breaker in the event of a fault with the transfer switch,
 - .3 a data drop to allow communication of the switch status directly to the local electric utility,
 - .4 following approval by the utility company to operate the switch in closed transition mode, the switch manufacturer to field convert the switch from delayed transition to closed transition operating mode and to re-commission the switch,
 - .5 secure inside the switch enclosure the delayed transition interlocking linkage, for future use.
- .14 For Solid State Transition Transfer Switches include:
 - .1 2 #12 in EMT to the Building Management System to indicate the static switch disable condition.
- .15 Touch up small areas marred in transit or during installation with touch up paint.

- .16 Provide rubber mats:
 - .1 3' wide 1/4" thick,
 - .2 17,000 volt rating,
 - .3 in front of each floor mounted transfer switch,
 - .4 at rear of transfer switches that require rear access,
 - .5 do not place mats until work is completed and room has been thoroughly cleaned.
- .17 Provide MICC, 2 hour fire rated interconnecting wiring between each automatic transfer switch and respective Diesel-generator control panel:
 - .1 2#12 for engine start signal,
 - .2 4#14 for ATS position (normal and emergency),
 - .3 6#14 for load management controls,
 - .4 2#12 for the remote test feature.
- .18 Provide 18 #12 in EMT from each automatic transfer switch to the Building Management System. As an alternative to #12 wires, #14 may be used if incorporated into a cable with at least 2 conductors per cable. Connect to indicate:
 - .1 alarm - preferred source failure
 - .2 status - engine start signal sent
 - .3 status - alternative source available
 - .4 status - switch connected to alternative source
 - .5 status - switch under load management control
 - .6 status - switch parked in neutral
 - .7 status - switch in bypass
 - .8 alarm - contact overlap time exceeded
 - .9 spare
- .19 Provide 12 #12 in EMT from each manual transfer switch to the Building Management System. As an alternative to #12 wires, #14 may be used if incorporated into a cable with at least 2 conductors per cable. Connect to indicate:
 - .1 alarm - preferred source failure
 - .2 status - alternative source available
 - .3 status - switch connected to alternative source
 - .4 status - switch under load management control
 - .5 status - switch parked in neutral
 - .6 spare
- .20 For each automatic transfer switch provide 16 #12 in EMT from the ATS to the Load Management Control System. As an alternative to #12 wires, #14 may be used if incorporated into a cable with at least 2 conductors per cable. Connect each pair of wires as follows:
 - .1 load management control – preferred source
 - .2 load management control – alternate source
 - .3 load management control – neutral position
 - .4 status – switch in preferred position
 - .5 status – switch in alternative position

- .6 status – switch parked in neutral position
 - .7 status – switch in bypass mode
 - .8 spare
- .21 For each manual transfer switch provide 14 #12 in EMT from the MTS to the Load Management Control System. As an alternate to #12 wires, #14 may be used if incorporated into a cable with at least 2 conductors per cable. Connect each pair of wires as follows:
- .1 load management control – preferred source
 - .2 load management control – alternate source
 - .3 load management control – neutral position
 - .4 status – switch in preferred position
 - .5 status – switch in alternate position
 - .6 status – switch parked in neutral position
 - .7 spare
- .22 Provide a system compatible Ethernet cable in EMT from the communications module in each TS to the local Ethernet switch. Program the communications module as required to provide the operation specified.
- .23 From each transfer switch supplying power to fire alarm equipment, provide 2 #12 MICC fire rated cable, from an auxiliary shaft contact (closed on alternative source) to the fire alarm system and connect to indicate that the fire alarm system is on emergency power.
- .24 From each transfer switch supplying power to elevators, provide 4 #12 MICC fire rated cable, from the pre-transfer contacts in the transfer switch to the respective elevator controller and connect to initiate sequencing of the respective elevator bank during emergency power operation.
- .25 From each transfer switch supplying power to a SUPS system, provide 4 #12 in EMT, from the transfer inhibit contacts in the associated transfer switch to the respective SUPS system control cabinet and connect to inhibit transfer in the event that the critical load is on static or maintenance bypass.

3.2 Manufacturers' Service Representation on Site

- .1 Manufacturer to supply factory trained service representative to perform the following field services:
- .1 check the installation of the equipment,
 - .2 conduct, or instruct the installation contractor in, the start-up of the equipment,
 - .3 calibrate controls,
 - .4 conduct site acceptance testing as described herein,
 - .5 participate in the commissioning program described herein,
 - .6 demonstrate the operation of safety controls to the facility operations staff,
 - .7 demonstrate the operation of the equipment over its entire performance range to the facility operations staff,
 - .8 provide training of the facility operations staff as described herein,
 - .9 repeat site visit to field convert closed transition transfer switches from delayed transition operating mode to closed transition operating mode and to re-commission the switches.
- .2 Note that multiple visits will be required due to the phased construction. Provide all necessary visits in accordance with the Contractor's procedures.
- .3 Submit copies of completed manufacturer start-up and test records prior to hand-over of equipment.

3.3 Site Acceptance Testing

- .1 After completion of installation, but before equipment is permanently placed into service, conduct Site Acceptance Testing (SAT) in the presence of and to the satisfaction of the Independent Testing Organization and the Owner's representative(s).
- .2 Conduct acceptance tests on each ATS and MTS in accordance with the reviewed test program.
- .3 Perform on site acceptance testing in accordance with the NETA Acceptance Testing Specification for Electrical Power Distribution Equipment and Systems, Section 7, #7.22.3 Emergency Systems, Automatic Transfer Switches.
- .4 Verify engine start and control signals from each transfer switch through to the engine generator system.
- .5 Dynamically verify all signals through to:
 - .1 elevator controllers,
 - .2 fire alarm system,
 - .3 uninterruptible power systems,
 - .4 building management system,
 - .5 load management system,
 - .6 generator control panel,
 - .7 remote annunciators,
 - .8 etc.
- .6 Document test results.
- .7 Record the results of the performance testing and submit completed report.

3.4 Commissioning Program

- .1 In addition to the manufacturer's Site Acceptance Testing, installation contractor and manufacturer to provide field service personnel to participate in the commissioning of the equipment and/or system including:
 - .1 review of equipment and system commissioning procedures in addition to the manufacturer's own testing procedures,
 - .2 control of and operation of equipment during testing,
 - .3 adjusting of equipment controls as required to simulate load or fault conditions, and
 - .4 assist with record keeping of test results as directed.

3.5 Demonstration and Training

- .1 In conjunction with the manufacturer's service representative, provide training to the facility operations staff:
 - .1 in the operation and maintenance of the TS's including their interactions with the power sources, monitoring, metering and control systems,
 - .2 allow for at least 4 hour sessions,
 - .3 submit records of the training program.
- .2 Note that the training sessions may be video recorded by the Owner.

END OF SECTION

SURGE PROTECTIVE DEVICES FOR LOW-VOLTAGE ELECTRICAL POWER CIRCUITS 26 43 13

1 GENERAL

1.1 Scope

- .1 Provide surge protection devices ("SPD") as shown.

1.2 Related Sections

- .1 Without limiting the scope of work or applicability of other specification sections, the work under this section directly integrates with or refers to the following specification sections:
 - .1 26 05 29 Fastenings and Supports.
 - .2 26 05 53 Identification for Electrical Systems.

1.3 Applicable Standards

- .1 Product standards:
 - .1 CSA C22.2 No. 269.1 Surge Protective Devices – Type 1 – Permanently Connected
 - .2 CSA C22.2 No. 269.2 Surge Protective Devices – Type 2 – Permanently Connected

1.4 Submittals

- .1 Shop drawings:
 - .1 Submit shop drawings and product data for each type of SPD.
 - .2 Include at least the following information:
 - (a) Peak Surge Current Capacity per phase,
 - (b) Voltage Protection Ratings (VPRs) for L-L, L-N, L-G and N-G modes,
 - (c) Nominal Discharge Current Ratings (I_n),
 - (d) Short Circuit Current Rating (SCCR),
 - (e) Maximum Continuous Operating Voltage rating (MCOV),
 - (f) type designation,
 - (g) confirmation that the devices are CSA labelled,
 - (h) recommended size of upstream overcurrent protection device,
 - (i) enclosure type and physical dimensions,
 - (j) where applicable, confirmation that the units are suitable for use on a high resistance grounded system.
- .2 Operation and maintenance data
 - .1 Provide operation and maintenance data for incorporation into manual specified in Section 26 01 01 Electrical General Requirements.

1.5 Quality Control

- .1 The SPD manufacturer to be ISO 14001 and ISO 9001 or 9002 certified.

1.6 Warranty

- .1 In addition to the warranty provisions of Division 01, provide a written warranty for parts, labour and services for a period of ten (10) years from date of acceptance by the Owner, against:

- .1 defects in material and workmanship,
- .2 failure due to exposure to any transient surge activity,
- .3 failure due to exposure to lightning.

2 PRODUCTS

2.1 General

- .1 SPDs to be listed to either:
 - .1 Type 1 to CSA C22.2 No. 269.1
 - .2 Type 2 to CSA C22.2 No. 269.2
- .2 Type 1 suitable for use in Type 1 and Type 2 locations.
- .3 Suppression elements for the following modes:
 - .1 L-G, L-N, L-L, and N-G for four wire (plus ground) systems,
 - .2 L-G and L-L for three wire (plus ground) systems including high resistance grounded systems.
- .4 Solid state, bipolar, bi-directional clamping devices using non-linear voltage dependent thermally protected Metal Oxide Varistors (MOV).
- .5 MOV's:
 - .1 individually fused in each mode,
 - .2 fuses sized so that the listed peak surge current of the SPD is not limited by the fuse,
 - .3 thermally protected, with a thermal protection element integrated with the MOV.
- .6 Short circuit current rating: not less than the required interrupting rating of the associated panel.
- .7 Maximum continuous operating voltage (MCOV) of SPD components:
 - .1 125% for 208V systems,
 - .2 120% for 480V and 600V systems,
 - .3 120% of the L-L voltage for both L-L and L-G elements for units connected to a high resistance grounded system.
- .8 Voltage Protection Ratings (VPRs) not to exceed the following:

System Voltage	L-N	L-G	N-G	L-L
208/120	800V	800V	800V	1200V
400/230	1200V	1200V	1200V	2000V
480/277	1200V	1200V	1200V	2000V
600/347	1500V	1500V	1500V	3000V
600 (HRG)	N/A	3000V	N/A	3000V

- .9 Enclosures:
 - .1 external flush mounted and integral SPDs: CSA Type 1 except where indicated otherwise,
 - .2 external surface mounted SPDs: CSA Type 4.
- .10 Local display unit complete with:
 - .1 indicating lights for all modes to display unit status and phase loss/protection loss,

- .2 audible alarm with mute button on the front cover,
- .3 surge event counter with backup power source,
- .11 NO/NC form C dry contacts indicating failure of the suppression network.

Standard of Acceptance

- Advanced Protection Technologies
- Eaton
- Emerson Network Power
- Mersen
- Schneider Electric
- Siemens
- ABB Installation Products Ltd. (T & B)
- Total Protection Solutions (Innosys Power Inc.)

2.2 SPD's Connected to Switchgear or Switchboards

- .1 Mounted integral to the switchgear and switchboards using minimal conductor lengths.
- .2 Incorporate into a standard breaker cubicle:
 - .1 mounted on an internal steel pan,
 - .2 with full ampacity switchboard bus bars brought as close as possible to the unit,
 - .3 with device isolation provided by a breaker.
- .3 Rated for application on a 120/208V(4W+G) solidly grounded wye system.
- .4 Peak surge current rating not less than: 200kA/phase.
- .5 Nominal discharge current rating I_n : 20kA.

2.3 SPD's Connected to Power Distribution Panels

- .1 Mounted integral to the panelboard.
- .2 Incorporate into the panelboard enclosure:
 - .1 with full ampacity panelboard bus bars brought as close as possible to the unit,
 - .2 with device isolation provided by a branch breaker.
- .3 Rated for application on a 120/208V(4W+G) solidly grounded wye system.
- .4 Peak surge current rating not less than: 120kA/phase.
- .5 Nominal discharge current rating I_n : 20kA.

2.4 SPD's Connected to Branch Circuit Panels

- .1 Mounted external to the panelboard.
- .2 Incorporate into the panelboard enclosure:
 - .1 with full ampacity panelboard bus bars brought as close as possible to the unit,
 - .2 with device isolation provided by a branch breaker.
- .3 Rated for application on a 120/208V (4W+G) solidly grounded wye system.
- .4 Peak surge current rating not less than: 80kA/phase.
- .5 Nominal discharge current rating I_n : 20kA.

- .6 With EMI/RFI filtering to provide not less than -40dB attenuation at 100kHz, as measured by the MIL-STD-220C 50 Ω Insertion Loss Method.

3 EXECUTION

3.1 Installation

- .1 Except where indicated otherwise, provide Type 1 SPD's as the first SPD downstream of a transformer with a high voltage primary winding.
- .2 Except where indicated otherwise provide Type 2 SPD's in all locations.
- .3 Install SPD's in accordance with the manufacturer's recommendations.
- .4 Ensure that neutral conductors are bonded to the system ground at the service entrance or transformer, as applicable, prior to energization of the SPD's.
- .5 Ship integral SPD devices to the switchboard/switchgear/panelboard manufacturer's plant for factory installation as part of the switchboard/switchgear/panelboard assembly.
- .6 External SPD devices:
 - .1 mount adjacent to associated panelboard or equipment,
 - .2 connect using wire in steel conduit sized as per the manufacturer's recommendations, but not less than #6AWG RW90 XLPE copper,
 - .3 keep wire lengths as short and as straight as possible,
 - .4 twist wires tightly together,
 - .5 relocate branch circuit breakers in the panelboards as necessary to minimize the wire lengths to the SPD's.
- .7 Where an external SPD is connected to a flush mounted panelboard:
 - .1 flush mount the SPD adjacent to the panel,
 - .2 provide faceplates or other accessories as required for flush mounting.
- .8 Provide a nameplate on external SPD's, identify the panelboard to which the SPD is connected.
- .9 Provide 2#12 in 16mm EMT from the alarm contacts in the SPD to the monitoring system terminal panel for connection by Div 25.
- .10 Energize and verify the operation of the SPD's via the local display unit.

3.2 Testing

- .1 Simulate an alarm in the SPD's and verify that they are correctly annunciated on the BAS.

3.3 Demonstration and Training

- .1 Instruct the Owner's staff in the operation, monitoring, alarms and means of isolating the SPD's.

END OF SECTION

LIGHTING

26 50 00

1 GENERAL

1.1 Scope

- .1 Provide lighting fixtures as shown.

1.2 Related Sections

- .1 Without limiting the scope of work or applicability of other specification sections, the work under this section directly integrates with or refers to the following specification sections:
 - .1 26 01 01 Electrical General Requirements.
 - .2 26 05 01 Electrical Basic Materials and Methods.

1.3 Definitions and Abbreviations

- .1 The following definitions and abbreviations apply to this section.
 - .1 **Ballast**: a control device that produces a voltage sufficient to initiate the operation of the lamp and then regulates the current flow and protects the lamp from excessive temperature.
 - .2 **CIE**: Commission Internationale de l'Eclairage (International Commission on Illumination).
 - .3 **CRI**: Colour Rendering Index.
 - .4 **Driver**: a control device that converts the AC source to a DC voltage suitable for the lamp, regulates the current flow and protects the lamp from excessive temperature.
 - .5 **HO**: fluorescent lamp with a High lumen Output
 - .6 **IESNA**: the Illuminating Engineering Society of North America
 - .7 **LED**: a solid state light source using Light Emitting Diodes

1.4 Applicable Codes and Standards

- .1 Product standards:
 - .1 CSA 22.2 No. 141 Emergency Lighting Equipment
 - .2 ISO 3864-1 Graphical Symbols – Safety Colours and Safety Signs:
Part 1: Design Principles for Safety Signs in Workplaces and Public Areas.
 - .3 ISO 7010 Graphical Symbols – Safety Colours and Safety Signs:
Safety Signs Used in Workplaces and Public Areas.

1.5 Qualified Tradesperson

- .1 Work to be performed by qualified, licensed and recognized firm with an established reputation in this field, using tradesperson holding applicable certificates of competency.

1.6 Submittals

- .1 Submit complete photometric data prepared by independent testing laboratory for luminaires where specified, for review by Consultant.
- .2 Photometric data to be in accordance with IESNA testing procedures and to include:
 - .1 total input watts,
 - .2 candlepower summary,

- .3 candela distribution zonal lumen summary,
 - .4 luminaire efficacy,
 - .5 CIE type,
 - .6 coefficient of utilization,
 - .7 lamp type and lumen rating in accordance with IESNA testing procedures.
- .3 Submit samples of luminaires, which are not catalogue items, for review by Consultant. Do not manufacture additional luminaires until sample has been reviewed and all comments addressed to the satisfaction of the Consultant. Retain each reviewed sample on job site until final completion of project. Replace luminaires which do not match quality and workmanship of reviewed sample with new luminaires that do.

1.7 Shipping and Storage Requirements

- .1 Do not deliver luminaires to building or stored therein until dry and protected space is available for proper storage of luminaires.

1.8 Substitutions

- .1 Luminaires included under this Specification section are specified by manufacturer and type. Provide equipment, as specified, unless substitutions requests are approved by the Owner.
- .2 Proposed substitutions will only be considered during the bidding period.
- .3 Proposed substitutions are to conform to specification section 00 26 13 and as specified herein;
 - .1 submit proposed substitutions to the Consultant not less than two weeks prior to the tender close date and time.,
 - .2 proposed substitution submission to include:
 - (a) samples named as per the specifications,
 - (b) catalogue cuts,
 - (c) complete photometric reports,
 - (d) complete descriptive and technical data, and
 - (e) cost savings.
 - .3 Substitution submission are to be presented as an alternative price showing the amount to be deducted from or added to the base bid.
 - .4 where proposed substitutions alter functional or visual design, or change the space requirements or mounting details indicated, detail such changes in the submission and include costs for revised design and construction for trades involved.
- .4 After award of the contract, substitutions will not be considered unless compelling reasons are given such as inability to meet delivery schedule; however, this reason will not be considered if the delay is caused by the Contractor's failure to order luminaires in accordance with the project schedule. In such cases, it remains the Contractor's responsibility to provide luminaires as specified without delay to the project and without additional cost to the Owner.

2 PRODUCTS

2.1 General

- .1 Similar luminaires to be products of the same manufacturer.
- .2 Maintain finishes of luminaires, as specified in the "Luminaire List", with colours to be consistent and finishes protected from damage.

- .3 Where the description of the luminaire directs a "colour/ finish to suit Consultant" or similar language, it is to be understood that during construction the final colour/finish will be selected by Consultant at that time. The Consultant shall be permitted to make their choice from a standard colour/finish range and the selected colour to apply to all of the particular type of luminaire, unless otherwise specified.
- .4 Luminaires:
 - .1 completely assembled in factory,
 - .2 delivered to building in cartons or in palletized form, as directed.
 - .3 suitable for individual or continuous row mounting.
- .5 Recessed luminaires, to include plaster trim frame or ring and mounting brackets to match ceiling type.
- .6 Troffers: equipped with adjustable mounting brackets.
- .7 For luminaires that will be supplied with power from two sources, provide:
 - .1 separate ballasts or drivers, as appropriate for each source,
 - .2 a grounded metal barrier:
 - (a) between the two sources,
 - (b) between the ballasts/drivers fed from different sources,
 - (c) between the wiring from the ballasts/drivers, fed from different sources and the lamps,
 - .3 a warning label indicating that the luminaire is fed from multiple sources.
- .8 Ballasts and drivers to be free of polychlorinated biphenyls (PCB's).
- .9 Ballasts and drivers to have a sound rating of "A".
- .10 Ballasts to be certified in an accredited laboratory for efficiency, performance with the specified lamps, and for safety to the applicable standards.
- .11 LED Drivers:
 - .1 rated input voltage: 120V through 277V or 347V through 480V, as applicable,
 - .2 voltage input range: sustained variations of $\pm 10\%$ with no damage to the driver,
 - .3 power factor greater than 90% from 20% to 100% rated load,
 - .4 total harmonic current distortion: less than 20%, from 20% to 100% rated load,
 - .5 in-rush current limits: per NEMA 410,
 - .6 output current regulated to $\pm 5\%$ across published load range,
 - .7 output ripple current at maximum output:
 - (a) less than 15% measured (peak-average)/average,
 - (b) less than 5% low frequency content (< 120 Hz.),
 - .8 integral means of limiting surges to the LED's, per IEEE/ANSI C62.41.2 surge characteristics:
 - (a) for interior applications: common mode and differential mode surge protection of 2.5kV (100kHz, 30 Ohm ring wave),
 - (b) for exterior applications: common mode and differential mode surge protection of 3kV (1.2/50 μ s, 2 Ohm combination wave),
 - .9 able to tolerate sustained open circuit and short circuit output conditions without failure, without need for external fuses or trip devices,
 - .10 auto resetting protection,
 - .11 no visible flicker when tested with flicker wheel,
 - .12 for dimming systems: no visible flicker, when tested with flicker wheel, across the full dimming range,

- .13 operating temperature, down to and including:
 - (a) -20°C (-4°F) for interior applications,
 - (b) -40°C (-40°F) for exterior applications,
- .14 metallic heat dissipating enclosure,
- .15 integral thermal foldback to reduce driver power if case temperature exceeds rated maximum temperature,
- .16 compatible with the dimming system,
- .17 rated for UL Damp and Dry locations,
- .18 for downlights: compact enclosure with integral studs allowing the driver to be mounted on the outside of the luminaire or on a junction box, without the need for an additional enclosure,
- .19 for linear luminaires: slim profile with height ≤ 25 mm (1 inch) and width ≤ 30 mm (1.2 inch),
- .20 integral colour-coded connectors,
- .21 labelled compliant with the latest edition of the following standards:
 - (a) CSA-C22.2 No. 223, Power Supplies with Extra-Low Voltage Class 2 Outputs,
 - (b) CSA C22.2 No 250-13, Light Emitting Diode (LED) Equipment for use in Lighting Applications,
- .22 RFI and EMI: per FCC regulations, Title 47 CFR Part 15. Non-consumer,
- .23 5 year warranty.

Standard of Acceptance

- Advance
- Litetech
- Universal
- VLM (Italy)
- Lumi-Drives (UK)
- Osram
- AC Electronics
- EldoLED

2.2 Lamps

- .1 Light Emitting Diodes:
 - .1 1.2 or 3 watts per LED,
 - .2 available in 2700K, 3000K, 3500K and 4000K correlated colour temperature (CCT) packages,
 - .3 CCT tolerances to remain within a 3-step MacAdam ellipse and to maintain a CRI of ≥ 80 , and an $R_9 > 50$,
 - .4 colour temperature and lumen output for each luminaire per luminaire schedule, using IESNA LM-79 testing procedures,
 - .5 maximum temperature at the base of the "LED cap" mounted to the substrate to be controlled to ensure full lamp life,
 - .6 lumen maintenance of not less than L_{70} @ 50,000 hours, using IESNA LM-80 and LM-21 testing procedures,
 - .7 LED's of the same type to be from the same manufacturing batch,
 - .8 capable of continuous dimming, from 10-100% lumen output, flicker and noise free,
 - .9 provide certified test results for each type of LED used on the project,
 - .10 5 year warranty.

Standard of Acceptance- Lamp Acceptance:

- Cree
- Lumileds
- Nichia
- Osram
- GE
- Samsung
- Bridgelux
- Seoul Semiconductor
- Toyoda Gosei

.2 Spare Lamps

.1 Provide spare lamps of each type used on the project, as follows:

- (a) Incandescent: 15%
- (b) Fluorescent, HID & LED: 5%

2.3 Exit Signs

.1 Exit signs:

- .1 listed to CSA 22.2 No. 141,
- .2 visibility and colour requirements to conform to ISO 3864-1 for exit signs,
- .3 graphic symbol to conform to ISO 7010, type E001, E002, E005 and E006,
- .4 internally illuminated by white L.E.D. sources,
- .5 single or double face as shown,
- .6 green "running man" pictogram on each face,
- .7 directional arrows indicating the direction of egress,
- .8 white directional arrows,

3 EXECUTION

3.1 Installation

- .1 Locate and install luminaires as indicated.
- .2 Locate hangers on tile centres or intersections.
- .3 Mount recessed down lights, troffers and surface mounted luminaires in or on full tiles.
- .4 Verify quantity of luminaires before ordering.
- .5 Verify colour temperature of lamps before ordering.
- .6 Verify ceiling types with the latest revised Architectural Drawings and order luminaires to suit the correct ceiling.
- .7 Verify which luminaires are fed from two separate panels. Separate the two sources within the luminaire with a grounded metal barrier.
- .8 Check luminaires and mountings for their electrical and physical characteristics in relation to conditions due to building construction and mechanical equipment. Make necessary adjustments to luminaires or hanging arrangement without expense to Owners. Give notification at time of shop drawings and before construction if decision on necessary changes is required.
- .9 Co-operate with other trades to ensure proper installation of luminaires.

- .10 Carefully align luminaires, shown in continuous lines or rows, so that rows appear as straight lines.
- .11 Mount luminaires perfectly level or plumb.
- .12 Luminaires to fit tightly to ceiling without showing a space or light leak between frame and ceiling.
- .13 Take down any improperly installed luminaires and re-install without expense to Owner.
- .14 Standard octagonal boxes may be supplied where conduits feeding luminaires in finished areas are exposed on ceiling if hanger canopies entirely cover outlet boxes and are neatly notched for conduit. Otherwise, provide cast conduit outlet boxes with a diameter larger than canopies.
- .15 Where luminaires are suspended directly from concrete slabs, attach boxes or hickies directly to poured concrete with 6mm (¼") or larger diameter bolts and lead expansion anchors.
- .16 Where luminaires are suspended directly from precast slabs, use 8mm (5/16") or larger bolts through slabs, welded to 100mm x 100mm (4" x 4") or larger 3.5mm (10 gauge) plate located above slabs.
- .17 Do not mount luminaires above pipes, ducts or equipment. In event of unavoidably tight locations, provide hangers to clear obstructions. Check layouts of other trades on job and plan co-operatively.
- .18 Hang luminaires in the same room at the same height.
- .19 Obtain approval before any changes are made to layouts shown.
- .20 Support luminaires mounted in or on ceilings independently of ceiling by means of chains.
- .21 Where luminaires are suspended or mounted on furred ceilings, provide continuous 12mm x 38mm (½" x 1½") channel above the ceiling, fasten each luminaire to channel with not less than two 6mm (¼") or larger diameter studs not more than 1220mm (4'- 0") on centre.
- .22 Where luminaires are installed in or on "T" bar ceilings provide each luminaire with two safety chains anchored in an approved manner to the floor slab or roof structure above. Each chain to support two corners of the luminaire. For safety chains, use #10 Tensile jack chain, installed as noted below.
- .23 Where luminaires are to be chain hung, use No. 10 Tensile jack chain, bright zinc coated, with a strength of 180 kg (400 lbs.). Make attachments using No.10 "S" hooks and close "S" hooks after installation. Caddy fasteners may be used where applicable.
- .24 Suspend industrial luminaires using 12mm (½") conduit hangers and ARB ball aligners. Select location and length of hangers to clear equipment, ducts and pipes. Metal strut (Flexibar, Unistrut, Eaton B-Line strut, T&B Superstrut) may be used for mounting of luminaires in mechanical areas and electrical rooms.

3.2 Luminaires

- .1 Luminaires:
 - .1 exactly as shown and as specified in the following schedule,
 - .2 complete with necessary accessories and lamps at time of acceptance,
 - .3 ULC or CSA certified,
 - .4 Each luminaire installed on a branch circuit operating at more than 150 volts-to-ground:
 - (a) provided with a disconnecting means integral to the luminaire,
 - (b) disconnecting means that simultaneously opens circuit conductors between the branch circuit conductors and the ballast(s)/driver(s),
 - (c) conspicuous, legible and permanent signage adjacent to the disconnecting means, identifying the specific purpose in accordance with the Electrical Code.

3.3 Lamps

- .1 Provide new lamps in luminaires.

- .2 For fluorescent luminaires with dimming ballasts, "season" the lamps by operating them at full output for 100 hours.

3.4 Exit Signs

- .1 Connect exit signs to a dedicated 120 Volt emergency power circuit and provide a lock on device on the branch circuit breaker.
- .2 In addition to the exit signs shown, provide a quantity of 20 exit signs including circuit breakers, lock on devices, junction boxes and wiring from a 120 Volt emergency power source. Signs to be installed as required by the local building authority. Turn over any signs, not required to be installed, to the Owner as spares.

3.5 Equipment Schedules

- .1 The following equipment schedules form part of this specification section.
 - .1 Schedule A: Lighting Fixtures
 - (a) luminaire types are listed in alphabetical order and not in order of preference.

SCHEDULE A – Lighting Fixtures

Title	Description	Lamp Schedule
LE1	<p>Surface mounted or suspended LED strip luminaire. Nominal 48" length. Steel housing assembly with frosted acrylic lens. Luminaire shall be suitable for suspension from slab with chain or aircraft cable. Luminaire to come complete with all necessary mounting accessories for a complete working installation.</p> <p>LED colour temperature shall be 3500K.</p> <p>Standard 0-10V (1%) dimming.</p> <p>Voltage: 120 volt</p> <p>Warranty: 5 years and meet L70, IES LM-80 and IES LM-79 testing.</p> <p>Manufacturers:</p> <p>Visioneering: LCOM48-LED835K044LUNV-P77</p> <p>Cooper</p> <p>Metalux</p>	<p>LED</p> <p>29W</p> <p>3500K</p> <p>4400 lumens</p> <p>80+ CRI</p>

X1	<p>LED Die-Cast aluminum Edge Lit 'Running Man' or 'Pictogram' exit sign in white finish. Unit shall operate with universal 2-wire AC input voltage of 120 to 347VAC at less than 2.5W and universal 2-wire DC input voltage from 6 to 24VDC at less than 1.5W for single and double face signs.</p> <p>The housing shall be constructed of Die-Cast aluminum. The faceplate(s) shall be constructed of a clear polycarbonate panel. Each faceplate shall come standard with two legend films for pictogram and direction selection. The light source shall be white light emitting diodes (LED) and shall provide even illumination in normal and emergency operation. The pictogram exit sign in a Self-Powered configuration shall use a sealed Nickel-Cadmium battery of 2.4V nominal voltage and shall stay illuminated during emergency operation for at least two hours upon AC failure.</p> <p>When specified for surface mount, the unit shall come standard with a trip plate, trim ring, back box and canopy made of Die-Cast aluminum with white finish. The trim plate shall have a circular profile and allow for wall or ceiling mount installation. The trim ring shall allow for semi-recessed installation in walls or ceiling with cavity. The canopy shall allow for wall, end, or ceiling mount.</p> <p>When specified for recessed ceiling mount, the unit shall come standard with a flat trim plate of Die-Cast aluminum with brushed aluminum finish, a back-box of galvanized steel, and a hardware kit for back-box installation between ceiling joists. The back-box shall be provided with conduit knock-outs at the top, back and end.</p> <p>The pictogram Exit Sign shall meet CSA 22.2 No. 141, latest edition.</p> <p>Voltage: 120V</p> <p><i>Manufacturer:</i></p> <p>Beghelli lighting: CRV-RM-L-U-S-OLR Lumacell lighting AimLite Ready-Lite Submit alternates for approval</p> <p>Include in the contract an additional ten (10) spare type 'X1' luminaires including installation accounting for an average of 40 meters of wire in conduit plus breaker for each additional luminaire connected to an emergency circuit. For bidding purposes, these luminaires can be added at any time during the construction process including and up to occupancy of each phase. Any luminaires not installed shall be turned over to the hospital.</p>	
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END OF SECTION

EMERGENCY LIGHTING

26 52 13.13

1 GENERAL

1.1 Scope

- .1 Provide packaged emergency lighting equipment including batteries and light fixtures, as shown.

1.2 Applicable Codes and Standards

- .1 Product standards:
 - .1 CSA C22.2 No. 141 Emergency Lighting Equipment

1.3 Submittals

- .1 Submit shop drawings and product data for products specified herein.
- .2 Include the extended warranty pro-rated charge cost.

1.4 Warranty

- .1 For batteries, the 12 months warranty period is extended to 120 months, with a no-charge replacement during the first 60 months and a pro-rate charge on the second 60 months.
- .2 In addition to the warranty provisions of Division 01, provide a written warranty for batteries to include:
 - .1 a no-charge replacement of batteries during the first 60 months following the date of handover of the Project to the Owner, and
 - .2 a further pro-rated charge on the next 60 month period.
- .3 This warranty is to include for parts, labour and services against:
 - .1 defects in material and workmanship,
 - .2 failure due to exposure to any transient surge activity,
 - .3 failure due to exposure to lightning.

2 PRODUCTS

2.1 Emergency Lighting Equipment

- .1 Manufacturers:

Standard of Acceptance

- Emergi-Lite
 - Lumacell Inc.
 - Beghelli
- .2 Supply voltage: 120 V, AC.
- .3 Output voltage: 12 V DC for indoor units, 24 V DC for outdoor units and in parking garages.
- .4 Operating time:
 - .1 12 volt units: 180 watts for 60 minutes.
 - .2 24 volt units: 360 watts for 60 minutes.
- .5 Battery: sealed, maintenance free, lead acid or lead calcium.
- .6 Charger:

- .1 solid state, multi-rate, voltage/current regulated, inverse temperature compensated, short circuit protected,
- .2 externally accessible means for testing of unit,
- .3 two lamps indicating A.C. On and High Charge,
- .4 a low voltage cut-off protection circuit and self-diagnostic auto test.
- .7 Solid state transfer unit.
- .8 Low voltage disconnect: solid state, modular, operates at 80% battery output voltage.
- .9 Signal lights: solid state, life expectancy 100,000 h minimum, for 'AC Power ON' and 'High Charge'.
- .10 Lamp heads: integral on unit and remote, 360° horizontal and 180° vertical adjustment.
- .11 Lamp type (integral and remote):
 - .1 finished Areas:
 - (a) adjustable type tungsten-halogen: 12 W, 12 VDC or 24 VDC to suite battery, glare free mounted in a Lexan cube approximately 113 mm square
 - .2 unfinished areas, electrical, mechanical and equipment rooms: 55 W, 12 VDC quartz
 - .3 outdoor units and parking lots: 70W, 24 VDC quartz PAR 36.
- .12 Cabinet: suitable for direct or shelf mounting to wall and c/w knockouts for conduit. Removable or hinged front panel for easy access to batteries.
- .13 Cabinet finish: Painted steel indoors, Type 4 outdoors enclosure
- .14 Units shall include "Flasher" remote test system with one hand-held controller.
- .15 Auxiliary equipment for central battery units:
 - .1 Ammeter,
 - .2 Voltmeter,
 - .3 lamp disconnect switch,
 - .4 test switch,
 - .5 time delay relay,
 - .6 battery disconnect device,
 - .7 AC input and dc output terminal blocks inside cabinet,
 - .8 mounting shelf,
 - .9 RFI suppressors.

2.2 Wiring of Remote Heads

- .1 Conduit: type EMT, to Section 26 05 33 - Conduits Fastenings and Fittings.
- .2 RFI suppressors.
- .3 Conductors: RW90 type to Section 26 05 19 - Wires & Cables 0-1000 Volts, sized in accordance with manufacturer's recommendations.

3 EXECUTION

3.1 Installation

- .1 Provide complete emergency battery lighting system as shown and specified.

- .2 Unless otherwise noted, mount units on the wall 2440mm above floor. Unit shall be hardwired to source. Provide lock-on devices on breakers.
- .3 Connect exit lights to unit equipment where indicated.
- .4 Where heads are shown remote from unit;
 - .1 provide suitable outlet box at 2440 mm and install head,
 - .2 connect with conduit to battery and charger unit,
 - .3 wire size to suit manufacturer's recommendations, but not less than #10 gauge, and for a minimum of 3% voltage drop at remote heads,
 - .4 ensure remote head wiring lengths are reviewed with manufacturer prior to installation,
 - .5 position heads as shown.

3.2 Startup and Testing

- .1 Test voltage drops on power supplied between batter unit and remote heads. Testing may be witnessed by Consultant and municipal building inspector at their discretion.
- .2 Replace any wiring not passing the 3% voltage drop test with new size and retest.

3.3 Test and Installation Records

- .1 Provide a completed manufacturer installation checklist record for the following elements of the work and submit the original to the Owner and a copy to Consultant. Provide an additional copy when required or requested by the Authority-having-Jurisdiction.
 - .1 emergency lighting fixtures.
- .2 Include a test record for each emergency light fixture with remote heads, recording the voltage drop test results, including initial and any repeat testing required.

END OF SECTION

CLOSEOUT REQUIREMENTS FOR ELECTRICAL WORK 26 77 19.20

1 GENERALDD

1.1 Scope

- .1 Provide documentation deliverables at completion of the Work for the following milestone events:
 - .1 Occupancy permit (where applicable) (Form OP1E),
 - .2 Substantial Performance of the Work (Form SP1E),
 - .3 Ready for take-over by Owner (Form RFT1E),
 - .4 Total Performance of the Work (Form TP1E).

1.2 Definitions

- .1 The following definitions apply to this section.
 - .1 **Occupancy permit** – means either: (i) a permit issued by a regulatory authority to allow the Owner to occupy the building subject to the building permit, or (ii) a building permit close-out procedure where documentation must be submitted to the building authority for that purpose.

1.3 General

- .1 The prerequisites and submittal of supporting documentation for the aforementioned milestone events may be combined as a single submission at one point in time for the following combination of events:
 - .1 Occupancy Permit, and Substantial Performance.
- .2 Where a prerequisite is listed in more than one milestone event, it shall be included in the earliest-occurring milestone event unless expressly specified otherwise.

1.4 Occupancy Permit

- .1 Submit the reviewed final record of the Testing of Integrated Life Safety and Fire Protection Commissioning report two weeks prior to application for occupancy permit, where such a report is required.
- .2 Complete the Occupancy Permit Checklist and submit with required documentation to support the Owner's application for occupancy.

1.5 Substantial Performance

- .1 Complete the Substantial Performance Checklist and submit with required documentation when applying for Substantial Performance of the Work.
- .2 Where the work is sub-divided into separate scopes of Work, each requiring a separate Substantial Performance application, provide a separate checklist for each application.
- .3 Within five working days of the Consultant's review report which indicates that Substantial Performance of the Work has been achieved, provide a detailed schedule for completion and/or correction of the Work of all items described in the Contractors' and the Consultants' deficiency list.

1.6 Ready-for-Takeover by Owner

- .1 The basic prerequisites to attaining Ready-for-Takeover of the Work are described in the General Conditions and Supplementary General Conditions of the Contract.
- .2 Complete the Ready-for-Takeover Checklist and submit with required documentation when applying for Ready-For Takeover of the Work.

1.7 Total Performance

- .1 Complete the Total Performance Checklist and submit with required documentation when applying for Total Performance of the Work.

Form OP1E: OCCUPANCY PERMIT CHECKLIST	
Project Name:	
Contract:	
Contract Scope:	
Application Date:	
Signed:	

The following requirements are completed and documentation included in this application. Where documentation has been issued directly to the Owner, a copy of the transmittal is enclosed.

- ☐ Building department inspection reports.
- ☐ AHJ electrical systems inspection reports.
- ☐ Fire Alarm Installation and Verification certificate to CAN/ULC-S524,
- ☐ Independent testing company, coordination study and testing reports submitted.
- ☐ Integrated Fire Protection and Life Safety test report to ULC-S1001.
- ☐ Equipment start-up reports (Interim).
- ☐ Electrical system testing reports.

Consultant Review	
Status:	<input type="checkbox"/> Reviewed <input type="checkbox"/> Incomplete or deficient - resubmit
Signed:	
Date:	

Form SP1E: SUBSTANTIAL PERFORMANCE APPLICATION CHECKLIST	
Project Name:	
Contract:	
Contract Scope:	
Application Date:	
Signed:	

The following requirements are completed and documentation included in this application. Where documentation has been issued directly to the Owner, a copy of the transmittal is enclosed.

- ☐ Occupancy permit has been issued by the AHJ (where applicable).
- ☐ Systems have been started-up, tested, and demonstrated to Owner or Consultant (final)
- ☐ Equipment and wiring identification completed
- ☐ Spare parts and replacement parts turned over to Owner, transmittal attached.

Consultant Review	
Status:	<input type="checkbox"/> Reviewed <input type="checkbox"/> Incomplete or deficient - resubmit
Signed:	
Date:	

Form RFT1E: READY-FOR-TAKEOVER APPLICATION CHECKLIST	
Project Name:	
Contract:	
Contract Scope:	
Application Date:	
Signed:	

The following requirements are completed and documentation included in this application. Where documentation has been issued directly to the Owner, a copy of the transmittal is enclosed.

- ☐ Substantial Performance has been certified or verified.
- ☐ Occupancy permit has been issued by the AHJ (where applicable).
- ☐ Final cleaning and waste removal completed.
- ☐ Delivery to Owner of Operating and Maintenance documents for systems being taken-over by Owner.
- ☐ Submit copies of up-to-date as-built drawings.
- ☐ Final start-up, testing and balancing reports completed and submitted to Owner, including any items requiring corrections identified by Consultant.
- ☐ The portions of the building being turned over to the Owner can be secured by Owner.
- ☐ Demonstration and training are completed, or Contractor and Owner has agreed to a schedule to provide such training to be completed within one month after the date of Ready-for-Takeover.
- ☐ All commissioning activities except for those activities that are identified or otherwise agreed by the Owner to be deferred commission activities which may be completed after Ready-for-Takeover of the Work.
- ☐ Integrated systems testing of fire protection and life safety systems.
- ☐ All warranties have been submitted to the Owner.
- ☐ A comprehensive list of items to be completed or corrected is provided to Owner and Consultant and included in the application for Ready-for-Takeover, and includes a schedule of when such work will be completed.

Consultant Review	
Status:	<input type="checkbox"/> Reviewed <input type="checkbox"/> Incomplete or deficient - resubmit
Signed:	
Date:	

Form TP1M: TOTAL PERFORMANCE APPLICATION CHECKLIST	
Project Name:	
Contract:	
Contract Scope:	
Application Date:	
Signed:	

The following requirements are completed and included in this application. Where documentation has been issued directly to the Owner, a copy of the transmittal is enclosed.

- ☐ All final Operating and Maintenance documents have been delivered to Owner.
- ☐ All final up-to-date as-built drawings have been delivered to Owner.
- ☐ All demonstration and training are completed.
- ☐ All commissioning activities are completed, including deferred alternate season commissioning activities.
- ☐ All known deficiencies have been corrected, including latent deficiencies reported by the Owner.
- ☐ All inspections and tests required to be performed by Contractor or manufacturer's prior to expiry of the warranty period have been completed, and documentation for those inspections and tests are included in this application.

Consultant Review	
Status:	<input type="checkbox"/> Reviewed <input type="checkbox"/> Incomplete or deficient - resubmit
Signed:	
Date:	

End of Section

**FIRE ALARM NOTIFICATION AND OUTPUT DEVICES
28 46 23**

1 GENERAL

1.1 Scope

- .1 Provide fire alarm system notification and output control devices as shown.

1.2 Definitions

- .1 Terminology used in this specification is based upon CAN/ULC S524 definitions. Refer to S524 for a complete glossary of terms.

1.3 Applicable Codes and Standards

- .1 Product standards:
 - .1 CAN/ULC-S525 Audible Signal Devices for Fire Alarm System and Signaling Systems, Including Accessories
 - .2 CAN/ULC-S526 Visible Signal Devices for Fire Alarm Systems and Signaling Systems, Including Accessories
 - .3 CAN/ULC-S541 Speakers for Fire Alarm Systems, Including Accessories

1.4 Submittals

- .1 Submit product data sheets for materials specified herein.

2 PRODUCTS

2.1 General

- .1 All Fire Alarm System components shall be listed to applicable ULC and/or CSA for use with the proposed fire alarm system.
- .2 Annunciation and output control devices to be of the fire alarm system manufacturer product line or their approved products except where specified herein.

2.2 Speakers

- .1 Listed to CAN/ULC-S541.
- .2 Speakers for the fire alarm system to have the following features:
 - .1 acoustically treated enclosure,
 - .2 line matching transformer with ¼, ½, 1, and 2 Watt taps,
 - .3 permanent magnet type speaker,
 - .4 wide dispersion bandwidth in hemispherical pattern, in both horizontal and vertical planes,
 - .5 minimum frequency response of 400 to 4000 Hz,
 - .6 high fidelity type speaker, 520 Hz type.
- .3 For flush-mounting as shown, and provided with speaker enclosures where shown as surface mounted.
- .4 Unit to be complete with hook-up terminals with screw-type connection.

2.3 Horn Speakers

- .1 Listed to CAN/ULC-S541.
- .2 Surface mounted with a weatherproof gland connection.
- .3 Dispersion angle of 120°H x 80°V.
- .4 Selectable weather protected taps of 1, 2, 4, & 7.5 watts.
- .5 Finish colour: fire alarm red.
- .6 Power supply: Powered by fire alarm output circuit.

2.4 Visible Signal Devices (Strobe Lights)

- .1 Listed to CAN/ULC-S526.
- .2 Performance:
 - .1 flash rate: one flash per second in alarm mode,
 - .2 the words "FIRE" to appear on the lens or attached nameplate.
 - .3 effective luminous intensity in a sleeping room or bed space: not less than 175 candela (cd).
 - .4 effective luminous intensity in all other areas: not less than 15 candela (cd) and selected to meet ULC S524 for the installed location.

2.5 Combination Signal Appliances

- .1 Combination audible and visual signaling devices to conform to individual articles specified herein.

2.6 Protective Cover for Visible Signal Devices / Speakers / Combination Signal Appliances

- .1 Tamperproof tough polycarbonate cover.
- .2 Slotted for horn or speaker units.
- .3 Solid for strobe-only alarms.

2.7 Addressable Control Relay Modules

- .1 Form "C" dry relay contact to control external appliances.
- .2 Contact rating: 2A @ 24V, 0.5A @ 120V.
- .3 Designed to be installed in a standard 1-gang box.
- .4 Include wall plate with LED viewing ports.

2.8 Alarm Signal Appliances

- .1 For remote indication of alarm condition.
- .2 Alarm lamp fixtures: high intensity (200 mcd) LED lamps, with screw-type terminals.
- .3 Mounting plate: single gang-box plate.

2.9 Fire Do Not Enter Signs

- .1 Listed to CAN/ULC-S526
- .2 Extruded aluminum body and aluminum faceplate, with LED bulbs.
- .3 Warning message:

- .1 "FIRE DO NOT ENTER"
- .2 red in colour,
- .3 to be visible only when the sign is illuminated.
- .4 Power supply: from fire alarm system.

3 EXECUTION

3.1 General

- .1 Provide notification and output devices as shown.
- .2 Installation of the fire alarm system components to be in accordance with the current applicable edition and all amendments of CAN/ULC-S524 and as specified herein.

3.2 Speaker Installation

- .1 Initially set speaker taps to be ½ W. Verify suitability of sound levels in each area and adjust tap to suit.
- .2 Speaker baffles to be held in place with approved fasteners.
- .3 Speakers to be flush mounted unless otherwise noted.
- .4 Speaker enclosures in stairwells to be suitable for surface mounting.

3.3 Visible Signal Devices Installation

- .1 Where there are more than two strobe lights in a corridors or room in the same field of view, adjust units to flash in synchronization regardless of whether the strobe light is served from one or more control units / transponders.
- .2 Suspend or mount ceiling-mounted strobe lights at not more than 9000mm above the finished floor.
- .3 Mount wall-mounted strobe lights such that the entire lens is not less than 2000mm and not more than 2400 mm above the finished floor.

3.4 Addressable Control Relay Module Installation

- .1 Mount control relay modules in a standard 1-gang box.

3.5 Remote Alarm Signal Appliances Installation

- .1 Provide alarm signal appliances directly connected to initiating devices that require remote annunciation
- .2 Mount remote indicating alarm lamps in a 1-gang box.

END OF SECTION