HALIBURTON HIGHLANDS SS
HVAC Upgrade

MECHANICAL/ELECTRICAL SPECIFICATIONS

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PART 1 - GENERAL

1.1. GENERAL

1.1.1. This specification defines the general requirements and procedures for submittals. A submittal is information submitted for the Consultant's review to establish compliance with the contract documents.

1.1.2. Detailed submittal requirements are found in the technical sections of the contract specifications. The Consultant may request submittals in addition to those specified when deemed necessary to adequately describe the work covered in the respective technical specifications at no additional cost to the Client.

1.1.3. Consultant review of a submittal does not relieve the Contractor of the responsibility for compliance with the contract documents or any error which may exist. The Contractor is responsible for fully complying with all contract requirements and the satisfactory construction of all work, including the need to check, confirm, and coordinate the work of all subcontractors for the project. Non-compliant material incorporated in the work will be removed and replaced at the Contractor's expense.

1.2. DEFINITIONS

1.2.1. Shop Drawings: Drawings, diagrams, and schedules specifically prepared to illustrate some portion of the work. Drawings prepared by or for the Contractor to show how multiple systems and interdisciplinary work will be integrated and coordinated.

1.2.2. Product Data: Catalog cuts, illustrations, schedules, diagrams, performance charts, instructions, and brochures, which describe and illustrate size, physical appearance, and other characteristics of materials, systems, or equipment for some portion of the work. Samples of warranty language when the contract requires extended product warranties.

1.2.3. Samples: Physical examples of materials, equipment, or workmanship that illustrate functional and aesthetic characteristics of a material or product and establish standards by which the work can be judged. Color samples from the manufacturer's standard line (or custom color samples if specified) to be used in selecting or approving colors for the project. Field samples and mock-ups constructed to establish standards by which the ensuing work can be judged.

1.2.4. Design Data: Calculations, mix designs, analyses, or other data pertaining to a part of work.

1.2.5. Test Reports: Report which includes findings of a test required to be performed by the Contractor on an actual portion of the work. Report which includes finding of a test made at the job site or on sample taken from the job site, on portion of work during or after installation.

1.2.6. Certificates: Document required of Contractor, or of a manufacturer, supplier, installer, or subcontractor through Contractor. The purpose is to document procedures, acceptability of methods, or personnel qualifications for a portion of the work.

1.2.7. Manufacturer's Instructions: Pre-printed material describing installation of a product, system, or material, including special notices and MSDS concerning impedances, hazards, and safety precautions.

1.2.8. Manufacturer's Field Reports: Documentation of the testing and verification actions taken by manufacturer's representative at the job site on a portion of the work, during or after installation, to confirm compliance with manufacturer's standards or instructions. The documentation must indicate whether the material, product, or system has passed or failed the test.

1.2.9. Operation and Maintenance Data: Manufacturer data that is required to operate, maintain, troubleshoot, and repair equipment, including manufacturer's help, parts list, and product line documentation. This data shall be incorporated in an operations and maintenance manual.

1.2.10. Closeout Submittals: Documentation necessary to properly close out a construction contract. For example, Operation and Maintenance manuals, as-built drawings. Also, submittal requirements necessary to properly close out a phase of construction on a multi-phase contract.

1.3. **SUBMITTAL REGISTER**

1.3.1. The submittal register prepared by the Contractor will list items of equipment and materials for which submittals are required by the specifications. This list may not be all inclusive and additional submittals may be required by the specifications. The Contractor is not relieved from supplying submittals required by the contract documents but which have been omitted from the submittal register.

1.3.2. The submittal register will serve as a scheduling document for submittals and will be used to control submittal actions throughout the contract period.

1.3.3. The Contractor shall provide the initial submittal register in electronic format. Thereafter, the Contractor shall track all submittals by maintaining a complete list, including completion of all data columns, including dates on which submittals are received and returned by the Consultant.

1.3.4. The Contractor shall update the submittal register as submittal actions occur and maintain the submittal register at the project site until final acceptance of all work by Client representative.

1.3.5. The Contractor shall submit formal monthly updates to the submittal register in electronic format. Each monthly update shall document actual submission and approval dates for each submittal.

1.4. **SUBMISSION PROCEDURES – SHOP DRAWINGS**

1.4.1. The contractor shall review all shop drawings before submittal to the Consultant. This review implies that the Contractor has determined or will determine measurements and has verified or will verify on the site, the construction criteria, materials, catalog numbers and similar data, and that he has reviewed and coordinated each shop drawing with the Contractual Documents and Specifications.

1.4.2. Submit shop drawings to the Consultant within reasonable delays and in a logical sequence in compliance with the construction schedule.

1.4.3. Submit for approval, all of the items specifically mentioned under the separate sections of the specification, with information sufficient to evidence full compliance with contract requirements. Materials, fabricated articles and the like to be installed in permanent work shall equal those of approved submittals.

1.4.4. Submission Preparation

1.4.4.1. Each submittal is to be complete and in sufficient detail to allow ready determination of compliance with contract requirements.

1.4.4.2. Collect required data for each specific material, product, unit of work, or system into a single submittal. Prominently mark choices, options, and portions applicable to the submittal. Partial submittals will not be accepted for expedition of construction effort. Submittal will be returned without review if incomplete.

1.4.4.3. All irrelevant or unnecessary data shall be removed from the submittal to facilitate accuracy and timely processing. Submittals that contain the excessive amount of irrelevant or unnecessary data will be returned with review.

1.4.4.4. Forward submittals in sufficient time to permit proper consideration and approval action by the Consultant; minimum time required for Consultant's review shall be 10 business days or longer, if the submitted equipment does not match the standard of acceptance and additional time is required for the evaluation.

1.4.4.5. Schedule submission to assure adequate lead time for procurement of contract required items. Delays attributable to untimely and rejected submittals will not serve as a basis for extending contract time for completion.

1.4.4.6. The Consultant's review consists in reviewing the conformity of shop drawings with the contract documents for recommendation to the Client or Owner. The Consultant is not liable for any responsibility for dimensions, details nor quantities.

1.4.4.7. After an item has been reviewed by the Consultant no change in brand or make will be permitted unless:

1.4.4.7.1. Satisfactory written evidence is presented to, and positively reviewed by the Consultant, that manufacturer cannot make scheduled delivery of approved item or;

1.4.4.7.2. Item delivered has been rejected and substitution of a suitable item is an urgent necessity or;

1.4.4.7.3. Other conditions become apparent which indicates approval of such substitute item to be in best interest of the Client.

1.4.5. If the Contractor installs equipment or material for which he has not submitted shop drawings for verification, the Consultant may, if the equipment or material is not installed in accordance with plans and specifications, require the equipment or material to be removed and replaced by a compliant product at no additional cost to the Client.

1.4.6. Shop drawings relating to products, special design systems or installations, custom equipment or similar to, all of which are not standard or catalogued products, will be considered engineering documents and as such, shall be authenticated by their author engineer. Authentication shall be in conformity with current Province of Ontario Laws and By-Laws. As an example, not limited to, shop drawings of a custom air-handling unit are covered by the present article and as such, constitute engineering documents that will require an authentication by their author engineer.

1.4.7. When shop drawings are resubmitted, indicate in writing all revisions other than those required by the Consultant.

1.4.8. Submit for review by the Consultant, within reasonable delays of the contract award, the complete set of shop drawings required. Faxed shop drawings are not accepted.

1.4.9. Shop drawings shall be submitted in electronic format. The following rules must be followed entirely:

1.4.9.1. The identification form must be included;

1.4.9.2. A shop drawing identification sheet hereby mentioned shall be included;

1.4.9.3. A single file in PDF format for each shop drawing shall be submitted. In the case where more than one document constitutes the drawing, they must all be incorporated into a single file;

1.4.9.4. Printing parameters of the drawings must be incorporated in the file to assure a scaled printing on a commercial printer;

1.4.9.5. The file must be of an excellent graphical quality;

1.4.9.6. Transmission of the shop drawings must follow the path of communication established for the project;

1.4.9.7. A transmittal sheet shall be attached to submitted drawings.

1.4.10. Shop drawings not following these directives will be returned to the contractor with a "Rejected" recommendation.

1.4.11. Each shop drawing shall be presented with an identification form. The shop drawing identification sheet shall include as a minimum the following information:

1.4.11.1. Owner's name
1.4.11.2. Project's name
1.4.11.3. Consultant’s name
1.4.11.4. Contractor's name
1.4.11.5. Name of sender
1.4.11.6. Sub contractor's name
1.4.11.7. Supplier's name
1.4.11.8. Specialty
1.4.11.9. Description
1.4.11.10. Specifications section number and article number
1.4.11.11. Revision number
1.4.11.12. Blank space for stamp of Conformity Review.

1.4.12. Submit all shop drawings in English, certified for construction by the manufacturer.

1.4.13. Drawings for non-standard articles or materials shall be produced, especially for the project.

1.4.14. Shop drawings shall include:

1.4.14.1. Construction details, dimensions, weights and equipment or material characteristics together with supplementary information such as bulletins, illustrations and exploded views of constituting parts.
1.4.14.2. Graphs, curves, capacities, efficiency and other technical data submitted by the manufacturer or requested by the Engineer concerning the operation of the equipment.
1.4.14.3. Wiring diagrams, single line diagrams, principle diagrams, control diagrams, operating sequences and all interconnections with other systems when required.
1.4.14.4. Flow diagrams for air, water, oil, fuel, etc. if applicable.
1.4.14.5. Marketing folders or publicity brochures will not be accepted.

1.4.15. Shop drawings will be returned with one or two of the following mentions: "Reviewed", "Modify and resubmit", "Modify as noted", "Rejected".

1.4.16. Drawings stamped "Reviewed" will not be further commented. Drawings comply with contractual documents.

1.4.17. Drawings stamped "Rejected" shall be done over again and resubmitted for approval. Drawings do not comply with contractual documents.

1.4.18. Drawings stamped "Modify as noted" shall not be resubmitted. Conditionally to the corrections indicated, drawings comply with contractual documents.

1.4.19. Drawings stamped "Modify and resubmit" shall be resubmitted, in part or in whole, as indicated for further examination. Drawings do not comply with contractual documents.

1.4.20. Drawings stamped "Modify as noted" and "Modify and resubmit" shall be resubmitted in part or in whole, as indicated, for further examination. Conditionally to the corrections indicated, drawings comply with contractual documents.

1.4.21. The Consultant's examination of the shop drawings does not relieve the Contractor from supplying equipment conforming to current standards and bylaws and to the requirements of this specification.

1.4.22. Any equipment, which is manufactured without the Engineer's prior examination, may be rejected. Assume all costs inherent to such a rejection.

1.5. **SUBMISSION SCHEDULING**

1.5.1. Submittals are to be scheduled, submitted, reviewed, and returned to the Contractor prior to the acquisition of the material or equipment. All comments marked by the Consultant shall be incorporated in the item for which a submission was made. No material or equipment shall be acquisitioned if the respective submissions was reviewed and rejected by the Consultant

1.5.2. Coordinate scheduling, sequencing, preparing, and processing of submittals with performance of work so that work will not be delayed by submittal processing. Allow time for potential re-submittal.

1.5.3. No delay costs or time extensions will be allowed for time lost in late submittals or re-submittals.

1.5.4. All submittals are required to be reviewed prior to the start of the specified work activity.

1.6. **AS-BUILT DOCUMENTATION**

1.6.1. During progress of the Work, Contractor shall maintain a set of Record Documents and Shop Drawings at the Site. Contractor must update these documents weekly, at a minimum, with mark-ups of actual installations that vary from the Work as originally shown. Contractor shall include all Drawings issued as addenda, clarifications, or Change Orders.

1.6.2. Contractor shall maintain and have available for review in conjunction with project progress meetings, a current set of the marked-up Record Documents and Shop Drawings. Availability for review and acceptability of both the format and content are prerequisites for certification and acceptance of the Application for Payment by the Client and Consultant.

1.6.3. Contractor must protect marked-up Record Documents from deterioration and loss in a secure location.

1.7. **RECORD DOCUMENTS EDIT LOG**

1.7.1. During progress of the Work, Contractor shall update the Record Documents Edit Log each time updates or edits are made, or information is added. The Record Documents Edit Log shall be submitted to the Consultant and Client prior to submitting each monthly Application for Payment.

1.7.2. The Record Documents Edit Log shall include the following information as a minimum:

1.7.2.1. Date Edited.
1.7.2.2. Name and Company of Person Making Edit.
1.7.2.3. Edit Type: RFI, Change Order/Request for Proposal, Field Change, Red Line,
1.7.2.4. Supplemental Document, and Revision/ASI.
1.7.2.5. Reference: name and number of the source document if applicable, such as Change Order or RFI number.
1.7.2.6. Sheet(s) Edited.

1.8. **AS-BUILT DRAWINGS**

1.8.1. Contractor must mark-up Drawings that are most compatible for showing actual physical condition, fully and accurately and must reference all other appearances of this Work to the updated sheet. Contractor must include cross-references to the Change Order number on the updated Drawing sheet and all additional sheets where the Work is shown.

1.8.2. Contractor must mark-up with erasable colored pencil, in a legible and professional manner using separate colors where feasible, to distinguish between changes for different categories of Work at the same general location.

1.8.3. Contractor must mark-up important additional information, which was either shown schematically only or omitted from the Construction Documents. Contractor must give particular attention to information on concealed work that would be difficult to identify or measure and record at a later date.

1.8.4. The contractor shall receive from the Consultant a set of electronic files of the project, with the engineering seal, stamp, signature and Consultant's logo removed.

1.8.5. The contractor shall use the files as backgrounds on which all the changes recorded during the construction phase shall be transcribed electronically.

1.8.6. Once all the changes have been transcribed on the backgrounds, the drawings shall be electronically stamped "AS BUILT DRAWINGS" and shall be converted to pdf format and submitted to the Consultant for review. The Contractor remains responsible for the accuracy of the recorded information.

1.8.7. In association with Contractor's request for Substantial Completion inspection, Contractor must submit one (1) electronic copy of the marked-up as-built drawings to Client's representative.

1.9. **RECORD SPECIFICATIONS**

1.9.1. It is mandatory that all changes to specified materials, installation, warranty, etc. be clearly and fully marked within the applicable Specification section in a manner acceptable to the Consultant and Client. Contractor shall review with the Owner and document an acceptable procedure early in the construction phase.

1.9.2. Contractor must give particular attention to substitutions, selection of options, and similar information on work where the exact products used are not clearly identified or readily discernible in the original Specifications. When applicable, Contractor must cross-reference related Record Drawing information and product data.

1.9.3. Contractor must neatly transcribe and post all marked-up information to a "clean" copy of the Specifications, ensuring that similar types of information are annotated in like fashion throughout the Specifications. The Record Specifications shall then be converted to pdf format and submitted to the Consultant for review. The Contractor remains responsible for the accuracy of Record Specifications content.

1.9.4. In association with Contractor's request for Substantial Completion inspection, Contractor must submit the electronic version (pdf) of the Record Specifications to the Client representative.

1.10. **OPERATION AND MAINTENANCE MANUALS**

1.10.1. Submit operations and maintenance and operation data for all required equipment min. 15 days before application for Substantial Completion of the work. Substantial Completion status for the work will not be granted in the absence of full Operations and maintenance Information.

1.10.2. Contractor shall furnish the following equipment data content to be Included in Operating and Maintenance Manuals:

1.10.2.1. *Description of Equipment.*

1.10.2.2. *Record Product Submittals.* Clearly identify all options and accessories of actual installed product and variations in the actual Work in comparison with submitted information.

1.10.2.3. *Parts List.* Clearly identify every part in the item of equipment with the proper manufacturer's name, part nomenclature and number, local source, and list price.

1.10.2.4. *Recommended Spare Parts List.* For each equipment item that Owner will likely need within a 12-month period to support and operate that item of equipment. The quantities of spare parts recommended must be based upon the quantity of like equipment items installed under the Contract Documents.

1.10.2.5. *Normal Operating Instructions.* Detailed information to permit a journeyman mechanic to adjust, start-up, operate, and shut down the equipment. Special start-up precautions shall be noted as well as other action items required before the equipment is put into service.

1.10.2.6. *Emergency Operating Procedures.* Detailed description of the sequence of action to be taken in the event of a malfunction of the unit, either to permit a short period of continued operation or emergency shutdown to prevent further damage to the unit and to the system in which it is installed.

1.10.2.7. *Preventive Maintenance.* Detailed information to cover routine and special inspection requirements, including but not limited to, field adjustments, inspections for wear, adjustment changes, packing wear, lubrication points, frequency and specific lubrication type required, cleaning of the unit and type solvent to use, and such other measures as are applicable to preventive maintenance program.

1.10.2.8. *Calibration.* Detailed data on what to calibrate, how to calibrate, when to calibrate and procedures to enable checking the equipment for reliability or indications as well as data for test equipment, special tools and the location of test points.

1.10.2.9. *Scale and Corrosion Control.* Detailed information covering the prevention of and removal of scale and corrosion.

1.10.2.10. *Trouble Shooting Procedures.* Detailed information and procedures for detecting and isolating malfunctions and detailed information concerning probable causes and applicable remedies.

1.10.2.11. *Removal and Installation Instructions.* Detailed information concerning the logical sequence of steps required to remove and install the item including instructions for the use of special tools and equipment.

1.10.2.12. *Disassembly and Assembly Instructions.* Detailed illustrations and text to show the logical procedure and provide the instructions necessary to disassemble and assemble the unit properly. The text shall include all checks and special precautions as well as the use of special tools and equipment required to perform the assembly or disassembly.

1.10.2.13. *Repair Instructions.* Detailed repair procedures to bring the equipment up to the required operating standard including instruction for examining equipment and parts for needed repairs and adjustments, and tests or inspections required to determine whether old parts may be reused or must be replaced.

1.10.2.14. *Special Tools and Test Equipment.* Detailed list of the special tools and test equipment needed to perform repair and maintenance for each equipment item. The list shall contain the special tool and test equipment part number, size, quantity, price, manufacturer's name and address, and local supplier's name and address.

1.10.2.15. *System Drawings.* Contractor shall furnish detailed drawings, where applicable, that clearly show wiring diagrams, utility service diagrams, control diagrams, system schematics, pneumatic and fluid flow diagrams, etc., which pertain to the unit function. System drawings must show major pieces of equipment, such as chillers, boilers, heat exchangers, pumps, air handlers, tanks, switchgear, etc., as meaningful to the Project. Fluid flow and direction and valves with their valve tag identification numbers must be clearly noted on drawings. Drawings must show modifications to another manufacturer's standard unit when it is incorporated into the assembly or package unit.

1.10.3. Warranties And Guarantees

1.10.3.1. Contractor shall include, within the Operating and Maintenance Manual organizational structure for each system, equipment item, or material, an executed copy of the specified warranty/guarantee with warranty effective dates covering that particular system, equipment item, or material. Contractor shall include the manufacturer's warranty as specified and the installing subcontractor's and supplier's guarantee for workmanship and system operation.

1.10.4. Requirements For Close-Out Manual

1.10.4.1. The Commissioning and Close-Out Manual shall include, but is not limited to, the following:

1.10.4.1.1. Commissioning documentation, pre-functional and functional check lists and forms.

1.10.4.1.2. Final air balance reports produced by the Test, Adjust, and Balance Firm.

1.10.4.1.3. Completed Valve Schedule and Fire, Fire/Smoke and Smoke Damper Schedule.

1.10.4.1.4. Owner Demonstration / Training Reports: Contractor shall furnish Training Plan and Documentation of Owner's personnel training regarding operation of systems. Contractor shall include identification of parties receiving training and date(s) of such training.

1.10.4.1.5. Electrical Test Reports (including factory tests and settings).

1.10.4.1.6. Miscellaneous Equipment Test Reports (including factory tests and settings).
1.10.4.1.7. HVAC Calibration Reports (including duct testing reports).
1.10.4.1.8. Fire Alarm Test Reports.
1.10.4.1.9. Piping Test Reports.
1.10.4.1.10. Sewer Video Log.
1.10.4.1.11. Code-required Certifications as described within Technical Specifications.
1.10.4.1.12. Material Safety Data Sheets (MSDS) for any and all products incorporated into the Project.

1.10.5. Miscellaneous Close-out Documents.

1.10.5.1. Contractor shall provide categories of requirements resulting in miscellaneous work records including, but not be limited to, the following:
1.10.5.1.1. Required field records on excavations, foundations, underground construction, wells and similar work.
1.10.5.1.2. Accurate survey showing locations and elevations of underground lines, including invert elevations of drainage piping. Surveys establishing lines and levels of building.
1.10.5.1.3. Certifications received in lieu of labels on products and similar record documentation.
1.10.5.1.4. Testing and qualification of tradesmen.
1.10.5.1.5. Documented qualification of installation firms.
1.10.5.1.6. Materials testing reports.
1.10.5.1.7. Final inspection Punch-list and deficiency corrections.
1.10.5.1.8. All original, signed Project warranties and guarantees.

1.11. **MAINTENANCE AND OPERATIONS MANUAL FORMATTING**

1.11.1. Provide minimum of two (2) hard copies and one electronic copy of Mechanical Maintenance Manuals, in accordance to the following:

1.11.2. Manuals to be bound in a hard cover neatly labeled: "OPERATING AND MAINTENANCE INSTRUCTIONS".

1.11.3. The Maintenance and Operations Manuals shall be divided into sections with neatly labeled and tabbed dividers between each section. The sections to be included in the manual are:

1.11.3.1. Section I - General.
1.11.3.2. Section II - Piping and Pump Systems, Ductwork and Accessories.
1.11.3.3. Section III - HVAC Equipment/Electrical Equipment
1.11.3.4. Section IV - Automatic Controls
1.11.3.5. Section V - Air and Water Balancing

1.11.4. The following information shall be contained within the sections:

1.11.4.1. SECTION I: A list giving name, address and telephone number of the Consultant, Engineers, General Contractor, Mechanical Trade and Controls Trade. Written warranties for the Mechanical Systems. A copy of the Valve directory giving number, valve location, normal valve position, and purpose of valve. Equipment lists and certificates shall be provided - certificates shall be signed and sealed by the appropriate suppliers.

1.11.4.2. SECTION II, III: A copy of all pressure tests and operational tests. A copy of Gas Operational Tests for gas fired equipment. A list giving name, address and telephone number of all suppliers. Details of chemical treatment equipment and substances. A copy of all reviewed Shop Drawings for all mechanical equipment and ancillary devices (valves, expansion tanks, pumps, strainers, plumbing, etc.). Copies of warranties.

1.11.4.3. SECTION IV: Complete Control Diagrams, Wiring Diagrams and description of Control system and the functioning sequence of the system.

1.11.4.4. SECTION V: Complete air and hydronic balancing reports.

1.12. **WITHHOLDING OF PAYMENT**

1.12.1. Payment for materials incorporated in the work will not be made if required approvals have not been obtained.

PART 2 - PRODUCTS (NOT APPLICABLE)

PART 3 - EXECUTION (NOT APPLICABLE)

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PART 1 - GENERAL

1.1. **REQUIREMENTS INCLUDED**

1.1.1. Procedures for on-site demonstration and testing of equipment and systems, including temporary facilities.

1.2. **INSTRUCTION OF CLIENT'S OPERATING PERSONNEL**

1.2.1. All demonstrations, instructions and testing must be completed prior to Board acceptance for beneficial use. All safety devices most pass 100 percent before the mechanical systems can be accepted for beneficial use.

1.2.2. Plumbing and emergency power systems are not included.

1.3. **DEFINITIONS**

1.3.1. Start Up: Initial inspection, cleaning, lubrication, adjustment, and operation of equipment and systems by the contractor with the assistance of the representatives of the equipment manufacturers.

1.3.2. Pre-Tests: The final stage of the startup procedure. This occurs after all adjustments have been made except for minor fine-tuning that can be done during the pre-test. Serves as verification that the systems are ready for the final test. Witnessing of pre-test by the Consultant is not required.

1.3.3. Final Tests: Tests, witnessed by the Commissioning Agent or their representative, which demonstrate that all equipment and systems are in compliance with requirements.

1.4. **QUALITY ASSURANCE**

1.4.1. Experienced, trained technical service personnel who are representatives of the equipment manufacturers and system designers shall demonstrate, provide instructions, pre-test and final test, as specified, the following equipment:

1.4.1.1. Boilers and Economizers
1.4.1.2. Burners
1.4.1.3. Air Handling Equipment and VFDs
1.4.1.4. Air Conditioning/Refrigeration Equipment
1.4.1.5. Control systems and Instrumentation.
1.4.1.6. Pumps and VFDs
1.4.1.7. Safety valves
1.4.1.8. Plumbing Specialties (requiring adjustment and set-up)

1.4.2. The person responsible for programming the BAS shall demonstrate and provide instructions on hardware, software and programming.

1.4.3. The Board will provide a list of personnel to receive instructions and will coordinate their attendance at agreed upon times.

1.4.4. All safety devices shall comply with the TSSA requirements.

1.5. **SUBMITTALS**

1.5.1. Names and qualifications of personnel performing demonstrations, instructions and tests.

1.5.2. Certification that pre testing is complete.

1.5.3. Preliminary schedule of all demonstrations, instructions and final tests two weeks prior to proposed dates.

1.5.4. Provide reports within three weeks after satisfactory completion of demonstrations, instructions, and tests. List date, type of work, persons participating, amount of time, test results, calculations of test results, test data.

1.5.5. Completed System Readiness Checklists provided by the Commissioning Agent and completed by the contractor, signed by a qualified technician and dated on the date of completion,

PART 2 - PRODUCTS (NOT APPLICABLE)

PART 3 - EXECUTION

3.1. **PREPARATION FOR FINAL TESTS, DEMONSTRATIONS, AND INSTRUCTIONS**

3.1.1. Verify that equipment and systems are fully operational. Complete all start up and pre-test activities for all equipment and systems. Complete all construction and finish work.

3.1.2. Arrange for all test personnel for all equipment to be continuously present during one period of time so that all equipment and systems can be tested in their interrelated functions. For instance, the burner in a heating system shall be tested during the boiler testing, and instrumentation performance will be evaluated in conjunction with boiler testing.

3.1.3. Deliver maintenance and operating manuals four weeks prior to instruction period.

3.1.4. Furnish all special tools.

3.2. **FINAL TESTS**

3.2.1. Demonstrate proper operation of each equipment and system.

3.2.2. Provide tests on equipment as specified in the individual specification sections.

3.3. **STARTUP AND TESTING**

3.3.1. The Consultant will observe startup and contractor testing of selected equipment. Coordinate the startup and contactor testing schedules with the Consultant. Provide a minimum of 7 days prior notice.

3.4. **DEMONSTRATIONS AND TRAINING**

3.4.1. Demonstrate operation and maintenance of equipment and systems to Board personnel no more than two weeks prior to scheduled Board operation of the equipment.

3.4.2. Use operation and maintenance manuals as basis of instruction. Review contents of manuals with personnel in detail to explain all aspects of operation and maintenance.

3.4.3. Demonstrate start up, operation, control, adjustment, trouble shooting, servicing, maintenance, and shut down of each item of equipment. Allow Government personnel to practice operating the equipment under supervision of instructors.

3.4.4. Prepare and insert additional data in operations and maintenance manuals when need for additional data becomes apparent during instructions.

3.4.5. Submit training plans and instructor qualifications

3.5. **TIME ALLOCATED FOR DEMONSTRATIONS AND INSTRUCTIONS**

3.5.1. At least 16 total instructor hours to include all new building services installed under this project.

3.5.2. At least 4 total instructor hours to include BAS and computer workstation and programs.

3.5.3. Do not exceed three trainees per session, one four-hour session, per day, per trainee.

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PART 1 - GENERAL

1.1. **DESCRIPTION**

1.1.1. This section specifies demolition and removal of utilities, services and equipment, as noted on the drawings and as required for the completion of the new work.

1.2. **DEFINITIONS**

1.2.1. Remove: Detach items from existing construction and dispose of them off-site unless indicated to be salvaged or reinstalled.

1.2.2. Remove and Salvage: Detach items from existing construction, in a manner to prevent damage, and deliver to Owner ready for reuse or store as noted on Drawings.

1.2.3. Remove and Reinstall: Detach items from existing construction, in a manner to prevent damage, prepare for reuse, and reinstall where indicated.

1.2.4. Existing to Remain: Leave existing items that are not to be removed and that are not otherwise indicated to be salvaged or reinstalled.

1.2.5. Dismantle: To remove by disassembling or detaching an item from a surface, using gentle methods and equipment to prevent damage to the item and surfaces; disposing of items unless indicated to be salvaged or reinstalled.

1.3. **WARRANTY**

1.3.1. Existing Warranties: Remove, replace, patch, and repair materials and surfaces cut or damaged during demolition, by methods and with materials and using approved contractors so as not to void existing warranties. Notify warrantor before proceeding. Existing Warranties include the following:

1.3.1.1. Roof system

1.3.1.1.1. Notify warrantor on completion of selective demolition, and obtain documentation verifying that existing system has been inspected and warranty remains in effect. Submit documentation at Project closeout.

1.4. **PROTECTION**

1.4.1. Perform demolition in such manner as to eliminate hazards to persons and property; to minimize interference with use of adjacent areas, utilities and structures or interruption of use of such utilities; and to provide free passage to and from such adjacent areas of structures.

1.4.2. Carry out all demolition work in a neat and orderly manner. Keep noise, dust, and similar nuisances to a minimum. Do not collapse walls. Do not throw or drop materials.

1.4.3. Provide safeguards, including warning signs, barricades, temporary fences, warning lights, and other similar items that are required for protection of all personnel during demolition and removal operations.

1.4.4. Where material indicated to be removed is suspected of containing asbestos, inform Client's Representative immediately. Do not disturb materials suspected of containing asbestos until asbestos content has been verified by Client.

1.4.5. Use extreme caution when cutting into shafts and chases. Shafts and chases may end above occupied areas within building. Take all necessary precautions to prevent debris from falling through openings between floors during demolition operations.

1.4.6. Maintain fences, barricades, lights, and other similar items around exposed excavations until such excavations have been completely filled.

1.4.7. Prevent debris from blocking drainage systems (floor drains) or affecting other mechanical and electrical systems that must remain in operation.

1.4.8. Protect building floors against damage from demolition work. Use ½" plywood covers over floor where lifting, moving, rolling of removed equipment is anticipated. Be responsible for repairing any damage to flooring caused by the work defined in this section. Execute repairs to the satisfaction of the Board at no cost to the Board.

1.4.9. Provide enclosed dust chutes with control gates from each floor to carry debris to truck beds and govern flow of material into truck. Provide overhead bridges of tight board or prefabricated metal construction at dust chutes to protect persons and property from falling debris.

1.4.10. Prevent spread of flying particles and dust. Sprinkle rubbish and debris with water to keep dust to a minimum. Do not use water if it results in hazardous or objectionable condition such as, but not limited to; ice, flooding, or pollution. Vacuum and dust the work area daily.

1.4.11. Maintain at least one stairway in each structure in usable condition to highest remaining floor. Keep stairway free of obstructions and debris until that level of structure has been removed.

1.4.12. Wherever a cutting torch or other equipment that might cause a fire is used, provide and maintain fire extinguishers nearby ready for immediate use. Instruct all possible users in use of fire extinguishers.

1.4.13. Keep hydrants clear and accessible at all times. Prohibit debris from accumulating within a radius of 4500 mm (15 feet) of fire hydrants.

1.4.14. Before beginning any demolition work, the Contractor shall survey the site and examine the drawings and specifications to determine the extent of the work. The contractor shall take necessary precautions to avoid damages to existing items to remain in place, to be reused, or to remain the property of the Client.

1.4.15. Any damaged items shall be repaired or replaced as approved by the Consultant. The Contractor shall coordinate the work of this section with all other work and shall construct and maintain shoring, bracing, and supports as required.

1.4.16. The Contractor shall ensure that structural elements are not overloaded and shall be responsible for increasing structural supports or adding new supports as may be required as a result of any cutting, removal, or demolition work performed under this contract. Do not overload structural elements. Provide new supports and reinforcement for existing construction weakened by demolition or removal works. Repairs, reinforcement, or structural replacement must have Resident Engineer's approval.

1.5. **QUALIFICATIONS**

1.5.1. Work of this section shall be executed by trades personnel having a minimum of 3 years' experience in the demolition field and capable to deploy adequate equipment as required to complete the work in an efficient and orderly manner.

1.6. **EXAMINATION**

1.6.1. Examine existing property. Determine the nature of materials to be removed.

1.6.2. When utilities or building services are encountered that are not indicated on the drawings, the Consultant shall be notified prior to further work in that area.

1.7. **SCHEDULING**

1.7.1. Coordinate the timing and duration of DCW, DHW and power shut-down with the Board representatives.

1.8. **MAINTAINING TRAFFIC**

1.8.1. Maintain and preserve Board's access requirements within, to and from existing building in areas where demolition and removal work is being carried out.

1.8.2. Do not close, obstruct, place or store material in the building driveways and passageways. Conduct operations with minimum interference with roads, streets, driveways, user traffic and passageways.

1.9. **HAULING OPERATIONS**

1.9.1. Maintain roadways and paving in the hauling areas clean on a daily basis and as required by Municipal Authorities.

1.9.2. Parking is not ample or readily available in the area where the building is located. Coordinate delivery of equipment with the Board representatives.

1.9.3. Contractor is responsible for all craning & lifting operations. It is the Contractor's responsibility to coordinate with the respective Municipality & pay/obtain all required permits.

1.9.4. Contractor is responsible for providing a craning plan for review & approval by the Client.

1.10. **INTERRUPTIONS TO CLIENT'S OPERATIONS**

1.10.1. There will be absolutely no interruptions to the building schedule during demolition work. Therefore, it is imperative that operations and machine and equipment movements, deliveries and removals are executed at time or times that will permit uninterrupted Board's operations in and around the building, including parking, receiving areas, deliveries and site and means of access and egress.

1.10.2. Where interruptions of domestic cold and hot water are necessary, coordinate with the School Representatives the timing and duration of such interruptions.

1.11. **SAFETY REQUIREMENTS**

1.11.1. Coordinate posting of danger signs conspicuously around property. Close doorways and thoroughfares giving access to area of demolition with barricades.

1.11.2. Provide a competent, experienced supervisor in charge of the Work and on Site while Work is in progress.

1.11.3. Should any suspect designated substance not already identified, be encountered, cease work in the immediate area and immediately report, to the Board. Board is responsible for removal of designated substances.

1.12. **WORK INCLUDED IN THIS SECTION**

1.12.1. Demolition work for this project includes but is not limited to the following:

1.12.1.1. Remove existing indoor air handlers including supply fans, return fans, in the existing Mechanical Attic space approximately as indicated.

1.12.1.2. Remove all ductwork & piping in the Mechanical Attic approximately as indicated. Remove existing pumps, disconnect from power and controls.

1.12.1.3. Allow for removal of demolished equipment via the existing exhaust air louvre. Temporarily remove existing exhaust louvre and enlarge wall opening as required

to remove all demolished equipment. Upon completion re-instate louver and cap on the interior of the mechanical attic c/w insulation.

1.12.1.4. Remove existing ductwork at high level in the Cafeteria space as indicated. Remove all associated supports and hangers.

1.12.1.5. Contractor is responsible for protecting the cafeteria flooring during demolition and construction.

1.12.1.6. Remove all power & controls wiring associated with the demolished equipment.

1.12.2. All cutting and patching associated with the removal of the ductwork to be included.

1.12.3. The temporary removal of any other building services as required for the installation of the new equipment; upon completion of the work, the relocated equipment shall be relocated back to the original position or left in the new position, as warranted by the new layout.

1.12.4. The removal of the controls shall be done by the controls Contractor. Contractor shall identify and label all controls before demolition, to ensure that all existing equipment that is to remain will not be affected by this work and to ensure proper connection of the new equipment to the school.

1.12.5. All existing building services not affected by this work shall be protected and where necessary, maintained operational during and after the demolition work is complete. Any accidental damage or interruption of existing building services not required by this project will be promptly repaired at no additional cost to the Owner.

PART 2 - PRODUCTS (NOT APPLICABLE)

PART 3 - EXECUTION

3.1. **GENERAL**

3.1.1. At the end of each day's work, leave site in a safe condition and erect safety barriers and lights as required. Ensure that no parts of the existing building are in danger of collapsing.

3.1.2. Review the requirements of new equipment to be installed. Perform all demolition work required to allow for the new equipment to be installed, whether shown on the drawings or not.

3.1.3. Provide any additional labour, materials and services not specifically indicated on the drawings but required to complete the demolition work.

3.1.4. Do not disturb adjacent structures or equipment designated to remain in place.

3.1.5. Confine operations and workers to those parts of the building which are defined on the drawings and exercise great care not to damage existing construction beyond that necessary for the carrying out of new work. Make good any such damage in every respect, to the satisfaction of the Client.

3.2. **DUST CONTROL**

3.2.1. Prevent spread of flying particles and dust. Sprinkle rubbish and debris with water to keep dust to a minimum. Do not use water if it results in hazardous or objectionable condition such as, but not limited to; ice, flooding, or pollution. Vacuum and dust the work area daily

3.3. **DISPOSAL**

3.3.1. Removed Items

3.3.1.1. Unless otherwise instructed by the Client's representative, all materials from demolition including brick, concrete, stone, metals, insulation, wiring, tubing and similar materials shall be removed

3.3.1.2. Removed items become property of Contractor and shall be disposed of by him daily, off the site to avoid accumulation at the demolition site. Materials that cannot be removed daily shall be stored in areas specified by the Consultant. Contractor shall dispose debris in compliance with applicable federal, provincial or local permits, rules and/or regulations.

3.3.1.3. Dispose of demolished materials in accordance with the requirements of Authorities Having Jurisdiction. At the end of demolition work, leave site in broom-clean condition. Clean existing surfaces specified to receive new applied finishes to ensure proper adherence.

3.3.2. Removed and Salvaged Items:

3.3.2.1. The Board Representative will review the Site prior to commencement of demolition and instruct the Contractor, in writing, as to the items to be Removed and Salvaged. Perform the following:

3.3.2.1.1. Clean salvaged items.

3.3.2.1.2. Pack or crate items after cleaning. Identify contents of containers.

3.3.2.1.3. Store items in a secure area until delivery to Owner.

3.3.2.1.4. Transport items to Owner's storage area location in building.

3.3.2.1.5. Protect items from damage during transport and storage.

3.3.3. Removed and Reinstalled Items:

3.3.3.1. Clean and repair items to functional condition adequate for intended reuse.

3.3.3.2. Pack or crate items after cleaning and repairing. Identify contents of containers.

3.3.3.3. Protect items from damage during transport and storage.

3.3.3.4. Reinstall items in locations indicated. Comply with installation requirements for new materials and equipment. Provide connections, supports, and miscellaneous materials necessary to make item functional for use indicated.

3.3.4. Existing Items to Remain:

3.3.4.1. Protect construction indicated to remain against damage and soiling during selective demolition. When permitted by Owner's Representative, items may be removed to a suitable, protected storage location off-site during selective demolition and reinstalled in their original locations after selective demolition operations are complete.

3.4. **REFRIGERANTS**

3.4.1. Refrigerant handling requirements are specified in Section: 23 23 00 Refrigerant Piping.

3.5. **DEMOLITION OF ARCHITECTURAL FINISHES**

3.5.1. General: Demolish and remove existing construction only to the extent required by new construction and as indicated. Use methods required to complete the Work within limitations of governing regulations and as follows:

3.5.1.1. Neatly cut openings and holes plumb, square, and true to dimensions required. Use cutting methods least likely to damage construction to remain or adjoining construction. Use hand tools or small power tools designed for sawing or grinding, not hammering and chopping, to minimize disturbance of adjacent surfaces. Temporarily cover openings to remain.

3.5.1.2. Cut or drill from the exposed or finished side into concealed surfaces to avoid marring existing finished surfaces.

3.5.1.3. Do not use cutting torches without written permission from Client's Representative. Comply with Owner's rules and procedures.

3.5.1.4. Locate selective demolition equipment and remove debris and materials so as not to impose excessive loading on supporting walls, floors, or framing.

3.5.1.5. Dispose of demolished items and materials promptly.

3.5.1.6. Remove all loose material from partially demolished work leaving only sound and secure construction.

3.5.2. Plaster:

3.5.2.1. Remove loose plaster that will be exposed in finished construction. Loose plaster is defined as plaster material of at least 2 inches by 4 inches in size that can be moved by touch or that sounds hollow when lightly tapped with a hammer.

3.5.3. Flooring:

3.5.3.1. Where shown, scheduled or otherwise required for application or installation of new floor finishes or coverings, remove existing flooring tile, resilient sheet flooring as follows:

3.5.3.1.1. Remove all traces of existing flooring materials. Remove resilient sheet and tile flooring products

3.5.3.1.2. Remove adhesives, except those containing asbestos. Use chemical strippers approved by manufacturer of new flooring materials, or grind concrete floor surfaces to completely remove adhesive. Obtain Client's Representative's approval of removal method prior to beginning removal work.

3.5.3.1.3. Do not remove vinyl composition tile or adhesives suspected of containing asbestos. Client will verify asbestos content of questionable materials. Removal of asbestos-containing adhesives (if any) shall be undertaken separately by the Client

3.5.3.1.4. Clean floor slabs of dust and adhesive residue.

3.6. DEMOLITION OF CONCRETE OR ASPHALT

3.6.1. Water used during concrete and asphalt work (including sweeping and saw-cutting) must be contained and collected for proper disposal. Do not discharge water containing dust or debris from concrete or asphalt work into storm drains, catch basins or to the sanitary sewer system.

Table of Contents

PART 1 - GENERAL

1.1. **SUMMARY**

1.1.1. This Section includes the following:

1.1.1.1. Gypsum board assemblies, including non-load-bearing steel framing.
1.1.1.2. Water-resistant gypsum drywall backer units installed with gypsum board assemblies.
1.1.1.3. Cementitious backer units installed with gypsum board assemblies.
1.1.1.4. Gypsum board shaft-wall assemblies.
1.1.1.5. Framing

1.2. **ASSEMBLY PERFORMANCE REQUIREMENTS**

1.2.1. Sound Transmission Characteristics: Where STC ratings are indicated, provide assemblies with STC ratings determined and classified in accordance with ASTM E 90 and ASTM E 413, respectively.

1.2.2. Fire Resistance: Provide gypsum board assemblies with fire-resistance ratings indicated.

1.2.3. Shaft-Wall Performance Requirements: Provide gypsum board shaft-wall assemblies that are composed of proprietary gypsum board panels and metal components designed for erection from outside the shafts, and that comply with performance requirements specified as determined from testing manufacturers' standard assemblies representing those indicated for this Project.

1.3. **SUBMITTALS**

1.3.1. Product data for each type of product specified.

1.4. **QUALITY ASSURANCE**

1.4.1. Fire-Test-Response Characteristics: Provide assemblies identical to those specified by indicated GA File Numbers in GA-600 "Fire Resistance Design Manual" or design designations in UL "Fire Resistance Directory," and that have been tested for fire resistance according to ASTM E 119 by an independent testing and inspecting agency.

PART 2 - PRODUCTS

2.1. **MANUFACTURERS**

2.1.1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

2.1.1.1. Gypsum Board and Related Products:

2.1.1.1.1. CertainTeed Saint-Gobain
2.1.1.1.2. Georgia-Pacific Corp.
2.1.1.1.3. Lafarge North America.
2.1.1.1.4. National Gypsum Co.
2.1.1.1.5. United States Gypsum Co.
2.1.1.2. Steel Framing and Furring:
2.1.1.2.1. Clark Dietrich Building Systems.
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2.1.1.3. Gypsum Backer Units:
2.1.1.3.1. Georgia-Pacific.
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2.1.1.4.1. FinPan, Inc.
2.1.1.4.2. Georgia-Pacific Corp.
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2.1.1.5. Gypsum Board Shaft-Wall Assemblies:
2.1.1.5.1. Dietrich Industries, Inc.
2.1.1.5.2. Georgia-Pacific Corp.
2.1.1.5.3. National Gypsum Co.
2.1.1.5.4. United States Gypsum Co.

2.2. **STEEL FRAMING FOR SUSPENDED CEILINGS**

2.2.1. General: Provide components complying with ASTM C 754 for conditions indicated.

2.2.2. Steel Studs for Ceiling Furring Channels: ASTM C 645, complying with the following requirements:

2.2.2.1. Minimum Base (Uncoated) Metal Thickness: 0.027 inch, unless otherwise indicated.
2.2.2.2. Depth: 2-1/2 inches, unless otherwise indicated.
2.2.2.3. Protective Coating: ASTM A 653, G 40 hot-dip galvanized coating.

2.3. **STEEL FRAMING FOR WALLS AND PARTITIONS**

2.3.1. General: Provide framing shapes as indicated, and with the following finish:

2.3.1.1. Protective Coating: Manufacturer's standard corrosion-resistant coating.
2.3.1.2. Protective Coating: ASTM A 653, G 40 hot-dip galvanized coating.

2.3.2. Steel Studs and Runners: ASTM C 645, Manufacturer's standard profiles, and complying with the following requirements:

2.3.2.1. Minimum Base (Uncoated) Metal Thickness: As indicated on drawings, or if not indicted, 0.0329 inch.

2.3.2.2. Minimum Depth: 3-5/8 inches, unless otherwise indicated.

2.3.3. Deflection and Firestop Track: Top runner designed to allow partition heads to expand and contract with movement of structure above while maintaining continuity of the assembly. Comply with requirements of ASTM C 645 except configuration, of thickness indicated for studs and width to accommodate depth of studs indicated with flanges offset at midpoint to accommodate gypsum board thickness.

2.3.4. Offset Configuration: Shadow-line design with offset projecting out from depth of stud.

2.3.5. Product: Subject to compliance with requirements, a product that may be incorporated in the Work includes, but is not limited to, "Fire Trak" manufactured by Fire Trak Corp.

2.3.6. Prefinished Top Track: Proprietary, pre-finished stud receptor track mounted to suspended ceiling grid. ASTM C 645, 25 gage galvanized steel; and as follows:

2.3.7. Accessories: Manufacturer's standard applied trim accessories for outside corners, wall ends and similar conditions requiring additional trim for a complete, finished appearance.

2.3.8. Finish: Baked-on polyester paint in color to match suspended ceiling grid manufacturer's standard white.

2.3.9. Product: Eliminator Track; Pro Products Mfg.

2.3.10. Steel Rigid Furring Channels: ASTM C 645, hat shaped, depth and 0.0179-inch minimum thickness of base (uncoated) metal, unless otherwise indicated. Provide furring brackets if recommended by manufacturer for application indicated.

2.3.11. Depth: 7/8 inch.

2.3.12. Steel Flat Strap and Backing Plate: Steel sheet for blocking and bracing, length and width as indicated, complying with ASTM A 653 or ASTM A 568, as follows:

2.3.13. Base (Uncoated) Metal Thickness: 0.0598 inch unless otherwise indicated.

2.4. **GYPSUM BOARD PRODUCTS**

2.4.1. Provide gypsum board of types indicated in maximum lengths available that will minimize end-to-end butt joints.

2.4.2. Gypsum Wallboard: ASTM C1396 and regular type for vertical surfaces, sag resistant for horizontal surfaces, Type X where required for fire-resistance-rated assemblies.

2.4.3. Thickness: Unless otherwise indicated, provide units that are 5/8 inch thick for all applications except 1/2 inch thick for ceilings and soffits.

2.4.4. Gypsum Liner Panels: Proprietary liner panels as required for the specific fire-resistant-rated gypsum board shaft-wall assemblies indicated, with moisture-resistant paper facings.

2.4.5. Glass-Mat, Water-Resistant Gypsum Backing Board: ASTM C 1178, of type and thickness indicated below:

2.4.5.1. Type and Thickness: Regular, 1/2 inch (12.7 mm) thick, unless otherwise indicated.

2.4.5.2. Type and Thickness: Type X, 5/8 inch (15.9 mm) thick, where required for fire-resistance-rated assemblies and where indicated.

2.4.5.3. Products: Subject to compliance with requirements, provide "Dens-Shield Tile Backer" manufactured by Georgia-Pacific Corp.

2.5. **CEMENTITIOUS BACKER UNITS**

2.5.1. Provide cementitious backer units complying with ANSI A118.9 and in maximum lengths available to minimize end-to-end butt joints.

2.5.2. Thickness: Manufacturer's standard thickness, but not less than 7/16 inch, unless otherwise indicated.

2.5.3. Width: Manufacturer's standard width, but not less than 32 inches.

2.6. **TRIM ACCESSORIES**

2.6.1. Accessories: Formed steel sheet zinc coated by hot-dip process, or rolled zinc, complying with the requirements of ASTM C 1047 for cornerbead, L, LC, U shapes.

2.6.2. One-piece control joint formed from rolled zinc with V-shaped slot and removable strip covering slot opening.

2.7. **JOINT TREATMENT MATERIALS**

2.7.1. General: Provide joint treatment materials complying with ASTM C 475 and the recommendations of both the manufacturers of sheet products and of joint treatment materials.

2.7.2. Joint Treatment for Gypsum Board: Provide paper reinforcing tape; and factory-packaged, vinyl-based, jobsite- or factory-mixed products. At Contractor's option, provide either specifically formulated taping and topping compounds or all-purpose compounds.

2.7.3. Joint Treatment Cementitious Backer Units: Tape and compound as recommended by cementitious backer unit manufacturer.

2.8. **MISCELLANEOUS MATERIALS**

2.8.1. Acoustical Sealant for Exposed and Concealed Joints: Latex sealant complying with ASTM C 834; and subject to compliance with requirements, one of the following products:

2.8.1.1. PL Acoustical Sealant; ChemRex, Inc.; Contech Brands.
2.8.1.2. AC-20 FTR Acoust. and Insul. Sealant; Pecora Corp.

2.8.2. Laminating Adhesive: Special adhesive or joint compound recommended for laminating gypsum panels.

2.8.3. Spot Grout: ASTM C 475, setting-type joint compound recommended for spot-grouting hollow metal door frames.

2.8.4. Foam Gaskets: Closed-cell vinyl foam adhesive-backed strips, 1/8 inch thick, in width to suit metal stud size.

2.8.5. Sound-Attenuation Blankets: Unfaced mineral-fiber blanket insulation produced by combining glass fibers with thermosetting resins to comply with ASTM C 665 for Type I (blankets without membrane facing).

2.8.6. Fasteners: Provide size and type of screws recommended by manufacturer for application indicated, and as follows:

2.8.6.1. Metal and Gypsum Board: Steel drill screws complying with ASTM C 1002 and of size, corrosion resistance and holding power required to fasten steel framing and furring members securely to substrates involved.
2.8.6.2. Cementitious Backer Units: Corrosion-resistant screws recommended by panel manufacturer.
2.8.6.3. Powder-Actuated Fasteners in Concrete: Corrosion-resistant materials suitable for application and capable of sustaining, without failure, a load equal to 5 times that imposed by ceiling construction, as determined by testing according to ASTM E 1190.

2.9. **SHAFT-WALL BASIC ASSEMBLY DESCRIPTION**

2.9.1. Cavity Shaft-Wall Assemblies: Provide assemblies constructed of proprietary gypsum liner panels inserted between steel tracks at each end of studs; with specially shaped steel studs engaged in tracks and fitted between gypsum liner panels; and with gypsum board on finished side or sides applied to studs in the number of layers, thicknesses and arrangement indicated.

2.9.2. Gypsum Liner Panel Thickness: As standard with manufacturer for gypsum board shaft-wall assemblies indicated.

2.9.3. Stud Shape and Depth and Thickness: As standard with manufacturer for gypsum board shaft-wall assemblies indicated; but not less than 0.0284-inch minimum base metal thickness.

2.9.4. Room-Side Finish: As indicated.

PART 3 - EXECUTION

3.1. **INSTALLING STEEL FRAMING, GENERAL**

3.1.1. Steel Framing Installation Standard: Comply with ASTM C 754 and with ASTM C 840 requirements that apply to framing installation.

3.1.2. Install supplementary framing, blocking, and bracing at terminations to support fixtures, equipment services, heavy trim, grab bars, toilet accessories, furnishings, or similar construction. Comply with details shown or, if not shown, with USG Co.'s "Gypsum Construction Handbook."

3.1.3. Isolate steel framing from building structure at the following locations:

3.1.3.1. In ceilings where building structure abuts ceiling perimeter or penetrates ceiling.
3.1.3.2. Where partition framing and wall furring abut structure, except at floor.

3.1.4. Independently frame both sides of joints at building control and expansion joints.

3.2. **INSTALLING STEEL FRAMING FOR SUSPENDED CEILINGS**

3.2.1. Install suspended steel framing components in sizes and at spacings indicated, but not less than that required by the referenced steel framing installation standard.

3.2.2. Do not connect or suspend steel framing from ducts, pipes, or conduit, or attach to steel roof deck.

3.2.3. Spacing: as indicated on the drawings. Default:

3.2.3.1. Framing Channel Spacing: 16 inches o.c.
3.2.3.2. Framing Channel Spacing: 24 inches o.c.

3.2.4. Installation Tolerances: Install with cross-furring members level to within 1/8 inch in 12 feet as measured both lengthwise on each member and transversely between parallel members.

3.3. **INSTALLING STEEL FRAMING FOR WALLS AND PARTITIONS**

3.3.1. Install runners (tracks) at floors and ceilings, and structural walls and columns where gypsum board stud assemblies abut other construction.

3.3.2. Where studs are installed directly against exterior walls, install foam gaskets between studs and wall.

3.3.3. Installation Tolerances: Install each steel framing and furring member so that fastening surfaces do not vary more than 1/8 inch from the plane formed by the faces of adjacent framing.

3.3.4. Extend partition framing to height indicated. Continue framing over frames for doors and openings and frame around ducts penetrating partitions above ceiling to provide support for gypsum board.

3.3.5. Terminate partition framing as shown on Drawings; or if not shown, as follows:

3.3.5.1. At suspended ceilings.

3.3.6. Install proprietary prefinished top track.

3.3.7. 6-inches above exposed face of suspended acoustic ceiling panels.

3.3.8. Full height to structural supports or substrates above suspended ceilings, if any. Cut studs 1/2 inch short of full height to provide perimeter relief.

3.3.9. Install proprietary deflection and firestop track at fire-rated partitions, and as otherwise indicated.

3.3.10. For STC-rated and fire-resistance-rated partitions that extend to the underside of floor/roof slabs and decks or other continuous solid structural surfaces to obtain ratings, install framing around structural and other members extending below floor/roof slabs and decks, as needed, to support gypsum board closures needed to make partitions continuous from floor to underside of solid structure.

3.3.11. Install steel studs and furring in sizes and at spacings as follows:

3.3.11.1. Maximum spacing between studs: 16-inches o.c., unless otherwise indicated.
3.3.11.2. Maximum spacing between studs: 24-inches o.c., unless otherwise indicated.

3.3.12. Frame openings to comply with GA-219, and with applicable published recommendations of gypsum board manufacturer, unless otherwise indicated. Attach vertical studs at jambs with screws either directly to frames or to jamb anchor clips on door frames; install runner track section (for cripple studs) at head and secure to jamb studs.

3.3.13. Install 2 studs at each jamb, unless otherwise indicated.

3.4. **APPLYING AND FINISHING GYPSUM BOARD, GENERAL**

3.4.1. Gypsum Board Application and Finishing Standards: Install and finish gypsum panels to comply with ASTM C 840 and GA-216.

3.4.2. Install gypsum panels with face side out.

3.4.3. Locate both edge or end joints over supports, except in ceiling applications where intermediate supports or gypsum board back-blocking is provided behind end joints. Do not place tapered edges against cut edges or ends. Stagger vertical joints on opposite sides of partitions. Avoid joints other than control joints at corners of framed openings where possible.

3.4.4. Spot grout hollow metal door frames for solid-core wood doors, hollow metal doors, and doors over 32 inches wide. Apply spot grout at each jamb anchor clip and immediately insert gypsum panels into frames.

3.4.5. Form control and expansion joints at locations indicated and as detailed, with space between edges of adjoining gypsum panels, as well as supporting framing behind gypsum panels.

3.4.6. Isolate perimeter of gypsum board partitions at structural abutments, except floors, with 1/4- to 1/2-inch-wide spaces and trim edges with LC-bead edge trim where edges of gypsum panels are exposed. Seal joints between edges and abutting structural surfaces with acoustical sealant.

3.4.7. Where STC-rated gypsum board assemblies are indicated, seal construction at perimeters, behind control and expansion joints, openings, and penetrations with a continuous bead of acoustical sealant including a bead at both faces of the partitions. Comply with ASTM C 919 and manufacturer's recommendations for location of edge trim and closing off sound-flanking paths around or through gypsum board assemblies, including sealing partitions above acoustical ceilings.

3.4.8. Space fasteners in gypsum panels according to referenced gypsum board application and finishing standard and manufacturer's recommendations.

3.4.9. Space screws a maximum of 12 inches o.c. for vertical applications.

3.4.10. Space fasteners in tile substrate panels a maximum of 8 inches o.c.

3.5. **GYPSUM BOARD APPLICATION METHODS**

3.5.1. Install gypsum wallboard panels on ceilings prior to wall/partition board application and at right angles to framing.

3.5.2. On partitions/walls, apply gypsum panels horizontally (perpendicular to framing), unless parallel application is required for fire-resistance-rated assemblies. Use maximum-length panels to minimize end joints. Stagger abutting end joints not less than one framing member in alternate courses of board.

3.5.3. On Z-furring members, apply gypsum panels vertically (parallel to framing) with no end joints. Locate edge joints over furring members.

3.5.4. Wall Tile Substrates: For substrates indicated to receive thin-set ceramic tile and similar rigid applied wall finishes, comply with the following:

3.5.4.1. Install cementitious backer units to comply with ANSI A108.11 at showers, and where indicated.

3.5.4.2. Install water-resistant gypsum backing board panels at showers, tubs, and where indicated. Install with 1/4-inch open space where panels abut other construction or penetrations.

3.5.4.3. Install gypsum wallboard panels with tapered edges taped and finished to produce a flat surface except at showers, tubs, and other locations indicated to receive water-resistant panels.

3.5.5. Apply gypsum panels to supports with screws.

3.5.6. Direct-Bonding to Substrate: Where gypsum panels are indicated as directly adhered to a substrate (other than studs, joists, furring members, or base layer of gypsum board), comply with gypsum board manufacturer's recommendations, and temporarily brace or fasten gypsum panels until fastening adhesive has set.

3.6. INSTALLING TRIM ACCESSORIES

3.6.1. General: Fasten trim accessories according to accessory manufacturer's directions for type, length, and spacing of fasteners.

3.6.2. Install cornerbead at external corners.

3.6.3. Install edge trim where edge of gypsum panels would otherwise be exposed. Provide edge trim type with face flange formed to receive joint compound, except where other types are indicated.

3.6.4. Install control joints according to ASTM C 840 and manufacturer's recommendations and in specific locations approved by Architect for visual effect.

3.7. INSTALLATION OF GYPSUM BOARD SHAFT-WALL ASSEMBLIES

3.7.1. General: Install gypsum board shaft-wall assemblies to comply with performance and other requirements indicated as well as with manufacturer's installation instructions and ASTM C 754 for installing steel framing.

3.7.2. Do not bridge building expansion joints with shaft-wall assemblies; frame both sides of joints with furring and other support as indicated.

3.7.3. At penetrations in shaft wall, maintain fire-resistance rating of entire shaft-wall assembly by installing supplementary steel framing around perimeter of penetration and fire protection behind boxes containing wiring devices similar items.

3.8. **FINISHING GYPSUM BOARD ASSEMBLIES**

3.8.1. Levels of Gypsum Board Finish: Provide the following levels of gypsum board finish per GA-214.

3.8.2. Level 1 for ceiling plenum areas, concealed areas, and where indicated, unless a higher level of finish is required for fire-resistance-rated assemblies and sound-rated assemblies.

3.8.3. Level 4 for gypsum board surfaces, unless otherwise indicated.

3.8.4. Level 5 for gypsum board the following surfaces where wood, stone, or cast plastic trim or base are indicted:

3.8.4.1. At gypsum column enclosures.
3.8.4.2. Where wall segments are less than 48-inches wide.
3.8.4.3. Where indicated.

3.8.5. Where Level 1 gypsum board finish is indicated, embed tape in joint compound.

3.8.6. For Level 4 gypsum board finish, embed tape in joint compound and apply first, fill (second), and finish (third) coats of joint compound over joints, angles, fastener heads, and accessories. Touch up and sand between coats and after last coat as needed to produce a surface free of visual defects and ready for decoration.

3.8.7. Where Level 5 gypsum board finish is indicated, after application of embedding, fill and finish coats, apply a thin, uniform skim coat of joint compound over entire surface. Touch up and sand between coats and after last coat as needed to produce a surface free of visual defects, tool marks, and ridges and ready for decoration.

3.8.8. Finish cementitious backer units to comply with unit manufacturer's directions.

3.9. **IDENTIFICATION**

3.9.1. Provide permanent identification of all assemblies requiring opening protectives including fire walls, fire barriers, fire partitions, and smoke barriers.

3.9.2. Install in accordance with the requirements of Michigan Building Code chapter 7.

3.9.3. Location:

3.9.3.1. Locate in accessible concealed spaces above finished ceiling. In locations without accessible concealed location, coordinate location with architect.

3.9.3.2. Locate within 15 feet of the end of each wall and at intervals not exceeding 30 feet measured horizontally along the assembly.

3.9.4. Signage requirements:

3.9.4.1. Lettering:

3.9.4.1.1. 3-inch minimum; 3/8-inch stroke width.

3.9.4.1.2. Color: Red on white background

3.9.4.2. Verbiage incorporating project specific hourly rating. Refer to life safety plan for rating requirements:

3.9.4.2.1. FIRE RATED ASSEMBLY (__HR) - PROTECT ALL OPENING

3.9.4.2.2. SMOKE BARRIER - PROTECT ALL OPENINGS

3.9.4.2.3. CLEANING AND PROTECTION

3.9.4.3. Promptly remove any residual joint compound from adjacent surfaces.

Table of Contents

PART 1 - GENERAL

1.1. **DESCRIPTION**

1.1.1. Work of this Section includes all labor, materials, equipment, and services necessary to complete the painting and finishing as shown on the construction documents and/or specified herein, including, but not limited to, the following:

1.1.1.1. Prime coats which may be applied in shop under other sections.
1.1.1.2. Prime painting unprimed surfaces to be painted under this Section.
1.1.1.3. Painting items furnished with a prime coat of paint, including touching up of or repairing of abraded, damaged or rusted prime coats applied by others.
1.1.1.4. Painting ferrous metal (except stainless steel) exposed to view.
1.1.1.5. Painting galvanized ferrous metals exposed to view.
1.1.1.6. Painting interior concrete floors, concrete block exposed to view.
1.1.1.7. Painting gypsum drywall exposed to view.
1.1.1.8. Painting of wood exposed to view, except items which are specified to be painted or finished under other Sections of these specifications. Back painting of all wood in contact with concrete, masonry or other moisture areas.
1.1.1.9. Painting pipes, pipe coverings, conduit, ducts, insulation, hangers, supports and other mechanical and electrical items and equipment exposed to view.
1.1.1.10. Painting surfaces above, behind or below grilles, gratings, diffusers, louvers lighting fixtures, and the like, which are exposed to view through these items.
1.1.1.11. Painting includes shellacs, stains, varnishes, coatings specified, and striping or markers and identity markings.
1.1.1.12. Incidental painting and touching up as required to produce proper finish for painted surfaces, including touching up of factory finished items.
1.1.1.13. Painting of any surface not specifically mentioned to be painted herein or on construction documents, but for which painting is obviously necessary to complete the job, or work which comes within the intent of these specifications, is to be included as though specified.

1.2. **RELATED WORK**

1.2.1. Division 23 - Heating, Ventilation and Air Conditioning (HVAC): Shop prime painting of steel and ferrous metals.

1.3. **SUBMITTALS**

1.3.1. Submit in accordance with Section: 01 33 23 Shop Drawings, Product Data, and Samples.

1.3.1.1. Painter qualifications.
1.3.1.2. Product Data: For each paint system specified. Include block fillers and primers.

1.3.1.3. Material List: Provide an inclusive list of required coating materials. Indicate each material and cross-reference specific coating, finish system, and application. Identify each material by manufacturer's catalog number and general classification.

1.3.1.4. Manufacturer's Information: Provide manufacturer's technical information, including label analysis, statement of VOC content and instructions for handling, storing, and applying each coating material proposed for use.

1.3.1.5. Samples for Initial Selection: Manufacturer's color charts showing the full range of colors available for each type of finish-coat material indicated.

1.3.1.6. Samples for Verification: Of each color and material to be applied, with texture to simulate actual conditions.

1.4. **DELIVERY AND STORAGE**

1.4.1. Deliver materials to site in manufacturer's sealed container marked to show following:

1.4.1.1. Name of manufacturer.
1.4.1.2. Product type.
1.4.1.3. Batch number.
1.4.1.4. Instructions for use.
1.4.1.5. Safety precautions.

1.4.2. In addition to manufacturer's label, provide a label legibly printed as following:

1.4.2.1. Surface upon which material is to be applied.
1.4.2.2. Specify Coat Types: Prime; body; finish; etc.

1.4.3. Maintain space for storage, and handling of painting materials and equipment in a ventilated, neat and orderly condition to prevent spontaneous combustion from occurring or igniting adjacent items.

1.4.4. Store materials at site at least 24 hours before using, at a temperature between 7 and 30 degrees C (45 and 85 degrees F).

1.5. **QUALITY ASSURANCE**

1.5.1. Qualification of Painters: Use only qualified journeyman painters for the mixing and application of paint on exposed surfaces. Submit evidence that key personnel have successfully performed surface preparation and application of coating on a minimum of three (3) similar projects within the past three (3) years.

1.5.2. Paint Coordination: Provide finish coats which are compatible with the prime paints used. Review other Sections of these specifications in which prime paints are to be provided to ensure compatibility of the total coatings system for the various substrates. Upon request from other subcontractors, furnish information on the characteristics of the finish

materials proposed to be used, to ensure that compatible prime coats are used. Provide barrier coats over incompatible primers or remove and re-prime as required. Notify the Contracting Officer Representative (COR) in writing of any anticipated problems using the coating systems as specified with substrates primed by others.

1.6. **DEFINITIONS**

1.6.1. General: Standard coating terms defined in ASTM D 16 apply to this Section.

1.6.2. *Flat* refers to a lusterless or matte finish with a gloss range below 15 when measured at an 85-degree meter.

1.6.3. *Eggshell* refers to low-sheen finish with a gloss range between 5 and 20 when measured at a 60-degree meter.

1.6.4. *Satin* refers to low-sheen finish with a gloss range between 15 and 35 when measured at a 60-degree meter.

1.6.5. *Semigloss* refers to medium-sheen finish with a gloss range between 30 and 65 when measured at a 60-degree meter.

1.6.6. *Full gloss* refers to high-sheen finish with a gloss range more than 65 when measured at a 60-degree meter.

1.6.7. The term "exposed surfaces" includes areas visible when permanent or built-in fixtures, convector covers, covers for finned-tube radiation, grilles, and similar components are in place. Extend coatings in these areas, as required, to maintain the system integrity and provide desired protection.

1.7. **MAINTENANCE MATERIAL SUBMITTALS**

1.7.1. Furnish extra materials, from the same product run, that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1.7.2. Paint: 5 percent, but not less than 1 gallon of each material and color applied.

1.8. **QUALITY ASSURANCE**

1.8.1. Manufacturers and Products: The products and manufacturers specified in this Section establish the standard of quality for the Work. Subject to compliance with all requirements, provide specified products from the manufacturers named in Part 2.

1.8.2. Reference Standards: Products in this section shall be built, tested, and installed in compliance with the specified quality assurance standards; latest editions, unless noted otherwise.

1.8.3. ASTM D16 Standard Terminology for Paint, Related Coatings, Materials, and Applications.

1.8.4. Source Limitations: Obtain block fillers, primers, and undercoat materials for each coating system from the same manufacturer as the finish coats.

1.9. **DELIVERY, STORAGE, AND HANDLING**

1.9.1. Deliver materials to the Project Site in manufacturer's original, unopened packages and containers bearing manufacturer's name and label.

1.9.2. Store materials not in use in tightly covered containers in a well-ventilated area at a minimum ambient temperature of 45 deg F. Maintain containers used in storage in a clean condition, free of foreign materials and residue.

1.9.3. Protect from freezing. Keep storage area neat and orderly. Remove oily rags and waste daily. Take necessary measures to ensure that workers and work areas are protected from fire and health hazards resulting from handling, mixing, and application.

1.10. **SITE CONDITIONS**

1.10.1. Apply water-based paints only when the temperature of surfaces to be painted and surrounding air temperatures are between 50 and 90 deg F.

1.10.2. Apply solvent-thinned paints only when the temperature of surfaces to be painted and surrounding air temperatures are between 45 and 95 deg F.

1.10.3. Do not apply paint in snow, rain, fog, or mist; or when the relative humidity exceeds 85 percent; or at temperatures less than 5 deg F above the dew point; or to damp or wet surfaces.

1.10.4. Painting may continue during inclement weather if surfaces and areas to be painted are enclosed and heated within temperature limits specified by manufacturer during application and drying periods.

PART 2 - PRODUCTS

2.1. **STANDARDS OF ACCEPTANCE**

2.1.1. Products: Subject to compliance with requirements, provide one of the products in the paint schedules.

2.1.2. Use ready-mixed (including colors), except two component epoxies, polyurethanes, polyesters, paints having metallic powders packaged separately and paints requiring specified additives.

2.1.3. Where no requirements are given in the referenced specifications for primers, use primers with pigment and vehicle, compatible with substrate and finish coats specified.

2.1.4. Provide undercoat paint produced by the same manufacturer as the finish coats. Use only thinners approved by the paint manufacturer, and use only to recommended limits.

2.1.5. Manufacturers:

2.1.5.1. Benjamin Moore & Co.
2.1.5.2. Sherwin-Williams Co
2.1.5.3. International Protective Coatings.
2.1.5.4. O'Leary Paint Co.
2.1.5.5. PPG Industries, Inc.
2.1.5.6. Pratt & Lambert Paints.
2.1.5.7. Tnemec.

2.2. **PAINT MATERIALS, GENERAL**

2.2.1. Material Compatibility:

2.2.2. Provide materials for use that are compatible with one another and substrates indicated, under conditions of service and application as demonstrated by manufacturer, based on testing and field experience.

2.2.3. VOC Content for Interior Paints: For interior paints and coatings applied at Project site, the following VOC limits, exclusive of colorants added to a tint base, when calculated according to 40 CFR 59, Subpart D (EPA Method 24)].

2.2.3.1. Flat Paints and Coatings: 50 g/L.
2.2.3.2. Nonflat Paints and Coatings: 150 g/L.
2.2.3.3. Dry-Fog Coatings: 400 g/L.
2.2.3.4. Primers, Sealers, and Undercoaters: 200 g/L.
2.2.3.5. Anticorrosive and Antirust Paints Applied to Ferrous Metals: 250 g/L.
2.2.3.6. Zinc-Rich Industrial Maintenance Primers: 340 g/L.
2.2.3.7. Pretreatment Wash Primers: 420 g/L.
2.2.3.8. Floor Coatings: 100 g/L.
2.2.3.9. Shellacs, Clear: 730 g/L.
2.2.3.10. Shellacs, Pigmented: 550 g/L.

2.2.4. Material Quality: Provide manufacturer's best-quality paint material of the various coating types specified. Paint-material containers not displaying manufacturer's product identification will not be acceptable.

2.2.5. Do not use products containing isocyanate compounds.

PART 3 - EXECUTION

3.1. **EXAMINATION AND PREPARATION**

3.1.1. Safety: Observe required safety regulations and manufacturer's warning and instructions for storage, handling and application of painting materials.

3.1.2. Take necessary precautions to protect personnel and property from hazards due to falls, injuries, toxic fumes, fire, explosion, or other harm.

3.1.3. Deposit soiled cleaning rags and waste materials in metal containers approved for that purpose. Dispose of such items off the site at end of each day's work.

3.1.4. Examine substrates, areas, and conditions, with the Applicator present, under which painting will be performed for compliance with paint application requirements.

3.1.5. Do not begin to apply paint until unsatisfactory conditions have been corrected and surfaces receiving paint are thoroughly dry.

3.1.6. Start of painting will be construed as the Applicator's acceptance of surfaces and conditions within a particular area.

3.1.7. Provide seven days' notice to the Owner's Representative prior to the application of epoxy paints.

3.1.8. Coordination of Work: Review other Sections in which primers are provided to ensure compatibility of the total system for various substrates. On request, furnish information on characteristics of finish materials to ensure use of compatible primers.

3.1.9. Notify the Consultant about anticipated problems using the materials specified over substrates primed by others.

3.1.10. General:

3.1.10.1. Remove hardware and hardware accessories, plates, machined surfaces, lighting fixtures, and similar items already installed that are not to be painted. If removal is impractical or impossible because of the size or weight of the item, provide surface-applied protection before surface preparation and painting.

3.1.10.2. After completing painting operations in each space or area, reinstall items removed using workers skilled in the trades involved.

3.1.10.3. Repair Of Existing Plaster and Drywall Surfaces: Spackle and sand smooth minor surface imperfections in existing drywall and plaster surfaces. Repair is limited to imperfections of not more than 2 sq. inches in area and 3/8 inch in depth.

3.1.11. Cleaning, General:

3.1.11.1. Before applying paint or other surface treatments, clean the substrates of substances that could impair the bond of the various coatings. Remove oil and grease before cleaning.

3.1.11.2. Schedule cleaning and painting so dust and other contaminants from the cleaning process will not fall on wet, newly painted surfaces.

3.1.11.3. Clean previously painted surfaces to remove dirt, masking tape, labels, adhesives, and other materials that would either be deleterious to adhesion of, or show through, new paint.

3.1.12. Surface Preparation: Clean and prepare surfaces to be painted according to manufacturer's written instructions for each particular substrate condition and as specified.

3.1.12.1. Provide barrier coats over incompatible primers or remove and reprime.

3.1.12.2. For coatings applied over previously painted surfaces, test application to check for lifting and other adhesion problems. Perform test in an isolated area where practicable.

3.1.13. Concrete and Cementitious Materials:

3.1.13.1. Prepare concrete, concrete masonry block, cement plaster, and mineral-fiber-reinforced cement panel surfaces to be painted. Remove efflorescence, chalk, dust, dirt, grease, oils, and release agents. Roughen as required to remove glaze. If hardeners or sealers have been used to improve curing, use mechanical methods of surface preparation.

3.1.13.2. Use abrasive blast-cleaning methods if recommended by paint manufacturer.

3.1.13.3. Determine alkalinity and moisture content of surfaces by performing appropriate tests. If surfaces are sufficiently alkaline to cause the finish paint to blister and burn, correct this condition before application. Do not paint surfaces where moisture content exceeds that permitted in manufacturer's written instructions.

3.1.13.4. Clean concrete floors to be painted with a 5 percent solution of muriatic acid or other etching cleaner. Flush the floor with clean water to remove acid, neutralize with ammonia, rinse, allow to dry, and vacuum before painting.

3.1.14. Ferrous Metals:

3.1.14.1. Clean ungalvanized ferrous-metal surfaces that have not been shop coated; remove oil, grease, dirt, loose mill scale, and other foreign substances. Use solvent or mechanical cleaning methods that comply with the Steel Structures Painting Council's (SSPC) recommendations.

3.1.14.2. Treat bare and sandblasted or pickled clean metal with a metal treatment wash coat before priming.

3.1.14.3. Touch up bare areas and shop-applied prime coats that have been damaged. Wire-brush, clean with solvents recommended by paint manufacturer, and touch up with the same primer as the shop coat.

3.1.15. Galvanized Surfaces:

3.1.15.1. Clean galvanized surfaces with nonpetroleum-based solvents so surface is free of oil and surface contaminants. Remove pretreatment from galvanized sheet metal fabricated from coil stock by mechanical methods.

3.1.16. Materials Preparation:

3.1.16.1. Mix and prepare paint materials according to manufacturer's written instructions.

3.1.16.2. Maintain containers used in mixing and applying paint in a clean condition, free of foreign materials and residue.

3.1.16.3. Stir material before application to produce a mixture of uniform density. Stir as required during application. Do not stir surface film into material. If necessary, remove surface film and strain material before using.

3.1.16.4. Use only thinners approved by paint manufacturer and only within recommended limits

3.2. **ATMOSPHERIC AND SURFACE CONDITIONS:**

3.2.1. Do not apply coating when air or substrate conditions are:

3.2.1.1. Less than 3 degrees C (5 degrees F) above dew point.

3.2.1.2. Below 10 degrees C (50 degrees F) or over 35 degrees C (95 degrees F), unless specifically pre-approved by the Consultant and the product manufacturer. Under no circumstances are application conditions to exceed manufacturer recommendations.

3.2.1.3. When the relative humidity exceeds 85 percent; or to damp or wet surfaces; unless otherwise permitted by the paint manufacturer’s printed instructions.

3.2.1.4. Maintain interior temperatures until paint dries hard.

3.2.1.5. Do no exterior painting when it is windy and dusty.

3.2.1.6. Do not paint in direct sunlight or on surfaces that the sun will warm.

3.2.1.7. Apply only on clean, dry and frost free surfaces except as follows:

3.2.1.7.1. Apply water thinned acrylic and cementitious paints to damp (not wet) surfaces only when allowed by manufacturer's printed instructions.

3.2.1.7.2. Concrete and masonry when permitted by manufacturer’s recommendations, dampen surfaces to which water thinned acrylic and cementitious paints are applied with a fine mist of water on hot dry days to prevent excessive suction and to cool surface.

3.3. **SURFACE PREPARATION:**

3.3.1. General:

3.3.1.1. The Contractor shall be held wholly responsible for the finished appearance and satisfactory completion of painting work. Properly prepare all surfaces to receive paint, which includes cleaning, sanding, and touching-up of all prime coats applied under other Sections of the work. Broom clean all spaces before painting is started. All surfaces to be painted or finished are to be completely dry, clean and smooth.

3.3.1.2. See other sections of specifications for specified surface conditions and prime coat.

3.3.1.3. Perform preparation and cleaning procedures in strict accordance with the paint manufacturer's instructions and as herein specified, for each particular substrate condition.

3.3.1.4. Clean surfaces before applying paint or surface treatments with materials and methods compatible with substrate and specified finish. Remove any residue remaining from cleaning agents used. Do not use solvents, acid, or steam on concrete and masonry. Schedule the cleaning and painting so that dust and other contaminants from the cleaning process will not fall in wet, newly painted surfaces.

3.4. **GENERAL WORKMANSHIP REQUIREMENTS**

3.4.1. Paint exposed surfaces of all new work, except where the paint schedules or provisions of this Section indicate that a surface or material is not to be painted or is to remain natural. If the schedules do not indicate color or finish, the Consultant will select from standard colors and finishes available.

3.4.2. Application may be by brush or roller. Spray application only upon acceptance from the Client's Representative in writing.

3.4.3. Protect work at all times. Protect all adjacent work and materials by suitable covering or other method during progress of work. Upon completion of the work, remove all paint and varnish spots from floors, glass and other surfaces. Remove from the premises all rubbish and accumulated materials of whatever nature not caused by others and leave work in a clean condition.

3.4.4. Materials are to be applied under adequate illumination, evenly spread and flowed on smoothly to avoid runs, sags, holidays, brush marks, air bubbles and excessive roller stipple.

3.4.5. Apply materials with a coverage to hide substrate completely. When color, stain, dirt or undercoats show through final coat of paint, the surface is to be covered by additional

coats until the paint film is of uniform finish, color, appearance and coverage, at no additional cost to the Government.

3.4.6. All coats are to be dry to manufacturer's recommendations before applying succeeding coats.

3.4.7. Walls: Where walls are scheduled, include the following surfaces in addition, unless otherwise indicated:

3.4.7.1. Surfaces of wall mounted items previously painted in existing construction.
3.4.7.2. Exposed portions of pipes, ducts, conduit, outlet and junction boxes and convector covers (regardless of factory finish).
3.4.7.3. Columns, both engaged and free-standing within the scheduled area.
3.4.7.4. Access panels.
3.4.7.5. Doors and door frames.
3.4.7.6. Gypsum fascia and soffits.
3.4.7.7. Woodwork and trim.
3.4.7.8. Handrails, including brackets and escutcheons.

3.4.8. Ceilings: Where ceilings are scheduled, include the following in addition to ceilings, unless otherwise indicated:

3.4.8.1. Surfaces of ceiling mounted items previously painted in existing construction.
3.4.8.2. Access panels.
3.4.8.3. Gypsum ceilings, soffits, fascia and trim.
3.4.8.4. Exposed portions of structural slabs.
3.4.8.5. Exposed interior steel and iron work.
3.4.8.6. Exposed portions of pipes, ducts, conduit, junction boxes.

3.4.9. Where floors are scheduled, include the following in addition to floors, unless otherwise indicated:

3.4.9.1. Base band 4-inches above finished floor.
3.4.9.2. Base band 6-inches above finished floor.
3.4.9.3. Where stairwell walls are scheduled, include the following in addition to walls, unless otherwise indicated:
3.4.9.4. Exposed portions of stringers, risers, support brackets, tread and landing pan edges.
3.4.9.5. Underside of stairs, including tread and landing pans.
3.4.9.6. Handrails, guards and infill panels.
3.4.9.7. Exposed anchors and fasteners.

3.4.10. Mechanical Work: Painting of mechanical work is limited to the following:

3.4.10.1. Exterior: Unless otherwise indicated, paint the following:
3.4.10.1.1. Structural supports for mechanical equipment.
3.4.10.1.2. Mechanical equipment (except pre-finished equipment).
3.4.10.1.3. Piping (except insulated piping), pipe hangers, and supports.
3.4.10.1.4. Ductwork.
3.4.10.1.5. Accessory items.

3.4.11. Interior Occupied Areas and Stairways:

3.4.11.1. Unless otherwise indicated, paint the following when exposed to view in finished construction:
3.4.11.1.1. Structural supports for mechanical equipment.
3.4.11.1.2. Mechanical equipment (except pre-finished equipment).
3.4.11.1.3. Piping (except insulated piping), pipe hangers, and supports.
3.4.11.1.4. Convector covers.
3.4.11.1.5. Ductwork.
3.4.11.1.6. Insulation on pipe and ductwork.
3.4.11.1.7. Accessory items.
3.4.11.1.8. Fire suppression system piping.

3.4.12. Interior Service Areas (Equipment Rooms, Mechanical Rooms, and Utility Spaces):

3.4.12.1. Unless otherwise indicated, paint the following items when exposed to view in finished construction:
3.4.12.1.1. Floors and equipment support pads
3.4.12.1.2. Structural supports for mechanical equipment.
3.4.12.1.3. Mechanical equipment (except pre-finished equipment).
3.4.12.1.4. Piping (except insulated piping), pipe hangers, and supports.
3.4.12.1.5. Accessory items.
3.4.12.1.6. Fire suppression system piping.

3.4.13. Interior Spaces, Concealed Above Acoustic Ceilings:

3.4.13.1. Unless otherwise indicated, paint the following:
3.4.13.1.1. Fire suppression piping, 3-inch diameter and larger.

3.4.14. Electrical Work:

3.4.14.1. Painting of electrical work is limited to the following:
3.4.14.1.1. Exterior: Unless otherwise indicated, paint the following:
3.4.14.1.2. Structural supports for electrical equipment, including unpainted cut ends of Unistrut.
3.4.14.1.3. Interior Occupied Areas: Unless otherwise indicated, paint the following when items exposed to view in finished construction:

3.4.15. Structural supports for electrical equipment.

3.4.15.1. Interior Service Areas (Equipment Rooms, Stairs and Utility Spaces): Unless otherwise indicated, paint the following items exposed to when view in finished construction: Structural supports for electrical equipment.

3.4.16. Miscellaneous

3.4.16.1. Painting of any surface not specifically mentioned to be painted herein or on construction documents, but for which painting is obviously necessary to complete the job, or work which comes within the intent of these specifications, is to be included as though specified.

3.5. **APPLICATION**

3.5.1. General:

3.5.1.1. Apply paint according to manufacturer's written instructions. Use applicators and techniques best suited for substrate and type of material being applied.

3.5.1.2. Paint colors, surface treatments, and finishes are indicated in the schedules, specifications or drawings.

3.5.1.3. Do not paint over dirt, rust, scale, grease, moisture, scuffed surfaces, or conditions detrimental to formation of a durable paint film.

3.5.1.4. Provide finish coats that are compatible with primers used.

3.5.1.5. The term "exposed surfaces" includes areas visible when permanent or built-in fixtures, convector covers, covers for finned-tube radiation, grilles, and similar components are in place. Extend coatings in these areas, as required, to maintain the system integrity and provide desired protection.

3.5.1.6. Paint surfaces behind movable equipment and furniture the same as similar exposed surfaces. Before the final installation of equipment, paint surfaces behind permanently fixed equipment or furniture with prime coat only.

3.5.1.7. Paint interior surfaces of ducts with a flat, nonspecular black paint where visible through registers or grilles.

3.5.1.8. Paint back sides of access panels and removable or hinged covers to match exposed surfaces.

3.5.1.9. Finish exterior doors on tops, bottoms, and side edges the same as exterior faces.

3.5.1.10. Finish interior of wall and base cabinets and similar field-finished casework to match exterior.

3.5.1.11. Brackets and Standards: Paint standards before installation of brackets, and allow to dry thoroughly. Paint brackets before installation on standards.

3.5.1.12. Sand lightly between each succeeding enamel or varnish coat.

3.5.2. Scheduling Painting: Apply first coat to surfaces that have been cleaned, pretreated, or otherwise prepared for painting as soon as practicable after preparation and before subsequent surface deterioration.

3.5.3. The number of coats and the film thickness required are the same regardless of application method. Do not apply succeeding coats until the previous coat has cured as recommended by the manufacturer. If sanding is required to produce a smooth, even surface according to manufacturer's written instructions, sand between applications.

3.5.4. Omit primer on metal surfaces that have been shop primed and touchup painted.

3.5.5. If undercoats, stains, or other conditions show through final coat of paint, apply additional coats until paint film is of uniform finish, color, and appearance. Give special attention to ensure edges, corners, crevices, welds, and exposed fasteners receive a dry film thickness equivalent to that of flat surfaces.

3.5.6. Allow sufficient time between successive coats to permit proper drying. Do not recoat surfaces until paint has dried to where it feels firm, does not deform or feel sticky under moderate thumb pressure, and where application of another coat of paint does not cause the undercoat to lift or lose adhesion.

3.5.7. Application Procedures: Apply paints and coatings by brush, roller, spray, or other applicators according to manufacturer's written instructions.

3.5.7.1. Brushes: Use brushes best suited for the type of material applied. Use brush of appropriate size for the surface or item being painted.

3.5.7.2. Rollers: Use rollers of carpet, velvet back, or high-pile sheep's wool as recommended by the manufacturer for the material and texture required.

3.5.7.3. Spray Equipment: Use airless spray equipment only with the express approval of the Owner; use spray equipment with orifice size as recommended by the manufacturer for the material and texture required. Spray apply coating to the following items:

3.5.7.3.1. Shelf standards and brackets.

3.5.7.3.2. Laboratory bench reagent shelving supports and brackets.

3.5.8. Minimum Coating Thickness: Apply paint materials no thinner than manufacturer's recommended spreading rate. Provide the total dry film thickness of the entire system as recommended by the manufacturer.

3.5.9. Block Fillers: Apply block fillers to concrete masonry block at a rate to ensure complete coverage with pores filled.

3.5.10. Block Filler for Special High-Build, Tile-Like Application: In indicated rooms and areas, apply block filler in accordance with manufacturer's written instructions, and the following special requirements:

3.5.11. Below-Ceiling Application: Apply multiple coats of block filler, sufficient in number to fill all voids in concrete masonry walls, in preparation for specified topcoat applications resulting in a finished surface coating that is without voids and tile-like. Apply coating using airless spray followed by back-rolling to force material into voids. Remove excess material by squeegeeing the surface. Remove excess material from masonry joints with a paint brush.

3.5.12. Prime Coats: Before applying finish coats, apply a prime coat of material, as recommended by the manufacturer, to material that is required to be painted or finished and that has not been prime coated by others. Recoat primed and sealed surfaces where evidence of suction spots or unsealed areas in first coat appears, to ensure a finish coat with no burn through or other defects due to insufficient sealing.

3.5.13. Pigmented (Opaque) Finishes: Completely cover surfaces as necessary to provide a smooth, opaque surface of uniform finish, color, appearance, and coverage. Cloudiness, spotting, holidays, laps, brush marks, runs, sags, ropiness, or other surface imperfections will not be acceptable.

3.5.14. Transparent (Clear) Finishes: Use multiple coats to produce a glass-smooth surface film of even luster. Provide a finish free of laps, runs, cloudiness, color irregularity, brush marks, orange peel, nail holes, or other surface imperfections.

3.5.15. Provide satin finish for final coats.

3.5.16. Stipple Enamel Finish: Roll and redistribute paint to an even and fine texture. Leave no evidence of rolling, such as laps, irregularity in texture, skid marks, or other surface imperfections.

3.5.17. Completed Work: Match approved samples for color, texture, and coverage. Remove, refinish, or repaint work not complying with requirements.

3.6. **ADJUSTING, CLEANING, PROTECTION**

3.6.1. Cleanup: At the end of each workday, remove empty cans, rags, rubbish, and other discarded paint materials from the site. Conform to the following:

3.6.1.1. After completing painting, clean glass and paint-spattered surfaces. Remove spattered paint by washing and scraping. Be careful not to scratch or damage adjacent finished surfaces.

3.6.1.2. Dispose wash water from latex paint to the sanitary sewer. Excess latex paint shall be salvaged for reuse or solidified for disposal with other construction

materials. Dry empty latex paint cans and dispose with other construction materials. Arrange for disposal of alkyd paints and solvents.

3.6.2. Protect work of other trades, whether being painted or not, against damage by painting. Correct damage by cleaning, repairing or replacing, and repainting, as approved by Architect.

3.6.3. Provide "Wet Paint" signs to protect newly painted finishes. Remove temporary protective wrappings provided by others to protect their work after completing painting operations.

3.6.4. At completion of construction activities of other trades, touch up and restore damaged or defaced painted surfaces. Comply with procedures specified in PDCA P1.

3.7. **INTERIOR PAINT SCHEDULE**

3.7.1. Interior Paint Systems, General: Apply coatings at manufacturer's recommended spreading rate to achieve indicated dry film thicknesses.

3.7.1.1. Where *"Industrial"* coating is indicated, provide Moore's "Industrial and Maintenance Coatings" products; or equivalent of other, listed approved manufacturers.

3.7.1.2. Where *"Professional"* coating is indicated, provide Moore's "Professional Coatings" products; or equivalent of other, listed approved manufacturers.

3.7.2. Colors: Match colors indicated in the specifications, drawings

3.7.3. In the absence of specific instructions pertaining to finishing colors, adhere to the following:

3.7.4. Concrete (non-wear surfaces):

3.7.4.1. Provide indicated "Professional" or "Industrial" coating systems over interior concrete and brick masonry surfaces:

3.7.4.2. Low-Luster, Acrylic Blended Latex Finish: Two finish coats over a primer.

3.7.4.2.1. Primer Coat: 100% acrylic, interior primer; total dry film thickness of not less than 0.95 mils.

3.7.4.2.2. Finish Coats: Eggshell, acrylic-latex, interior enamel; total dry film thickness of not less than 2.6 mils.

3.7.4.3. Semi-Gloss, Vinyl Acrylic Latex Finish: Two finish coats over a primer.

3.7.4.3.1. Primer Coat: 100% acrylic, interior primer; total dry film thickness of not less than 0.95 mils.

3.7.4.3.2. Finish Coats: Semi-gloss, acrylic-latex, interior enamel; total dry film thickness of not less than 2.2 mils.

3.7.4.4. Semi-Gloss, Acrylic Epoxy Finish: Two finish coats over a primer.

3.7.4.4.1. Primer Coat: 100% acrylic, interior primer; total dry film thickness of not less than 0.95 mils.

3.7.4.4.2. Finish Coats: High gloss two-component polyamide epoxy; total dry thickness 4.0 mils.

3.7.5. Concrete (wear surfaces):

3.7.5.1. Provide the indicated "Industrial" coating systems over interior concrete floor surfaces:

3.7.5.2. High Gloss 100% Solids Epoxy Finish: Two finish coats over an undercoat.

3.7.5.2.1. Undercoat: Semi-gloss, moisture-tolerant, waterborne polyamide epoxy sealer; total dry thickness 1.5 mils.

3.7.5.2.2. Finish Coats: Semi-gloss polyamide epoxy with sand admixture to produce light non-slip texture; total dry thickness 2.5 mils.

3.7.6. Concrete Masonry Units:

3.7.6.1. Provide the indicated "Professional" or "Industrial" coating systems over interior concrete masonry block units:

3.7.6.2. Low-Luster, Acrylic-Enamel Finish: Two finish coats over a block filler for new work.

3.7.6.2.1. Block Filler (new work only): High build latex block filler; dry film thickness of not less than 8.5 mils.

3.7.6.2.2. Primer (over existing painted surfaces): Acrylic-latex primer; dry film thickness of not less than 1.2 mils.

3.7.6.2.3. Finish Coats: Low-luster (eggshell), acrylic-latex, interior enamel; total dry film thickness of not less than 2.6 mils.

3.7.6.3. Semi-Gloss, Vinyl Acrylic Latex Finish: Two finish coats (over a block filler for new work).

3.7.6.3.1. Block Filler (new work only): High build latex block filler; total dry film thickness of not less than 8.5 mil.

3.7.6.3.2. Primer (over existing painted surfaces): Acrylic-latex primer; dry film thickness of not less than 1.2 mils.

3.7.6.3.3. Finish Coats: Semi-gloss, acrylic-latex, interior enamel; total dry film thickness of not less than 2.0 mils.

3.7.6.4. Semi-Gloss, Acrylic Epoxy Finish: Two finish coats over a primer.

3.7.6.4.1. Block Filler (new work only): Waterborne high solids epoxy block filler; dry film thickness of not less than 9.8 mils.

3.7.6.4.2. Primer (over existing painted surfaces): Acrylic-latex primer; dry film thickness of not less than 1.2 mils.

3.7.6.4.3. Finish Coats: Semi-gloss, two-component acrylic epoxy coating; total dry film thickness of not less than 3.0 mils.

3.7.6.5. High Gloss, High-Build, Polyamide Epoxy Enamel Finish: Two finish coats over multiple coats of block filler.

3.7.6.5.1. Block Filler: Waterborne high solids epoxy block filler; dry film thickness of not less than 9.8 mils per coat.

3.7.6.5.2. Second and Third Coats: High gloss two component polyamide epoxy enamel; total dry film thickness of not less than 4 mils.

3.7.7. Gypsum Board and Plaster:

3.7.7.1. Provide the indicated "Professional" or "Industrial" coating systems over interior gypsum board and plaster surfaces:

3.7.7.2. Low-Luster, Acrylic-Enamel Finish: Two finish coats over a primer.

3.7.7.2.1. Primer: Latex-based, interior primer; total dry film thickness of not less than 1.2 mils.

3.7.7.2.2. Finish Coats: Low-luster (eggshell), acrylic-latex, interior enamel; total dry film thickness of not less than 2.6 mils.

3.7.7.3. Semigloss, Acrylic-Enamel Finish: Two finish coats over a primer.

3.7.7.3.1. Primer: Latex-based, interior primer; total dry film thickness of not less than 1.2 mils.

3.7.7.3.2. Finish Coats: Semigloss, acrylic-latex, interior enamel; total dry film thickness of not less than 2.4 mils.

3.7.7.4. Waterborne Acrylic Epoxy Finish: Two finish coats over a primer.

3.7.7.4.1. Primer: Acrylic-latex primer; dry film thickness of not less than 1.2 mils.

3.7.7.4.2. Finish Coats: Semi-gloss, two-component acrylic epoxy coating; total dry film thickness of not less than 3.0 mils.

3.7.7.5. High Gloss, High-Build, Polyamide Epoxy Enamel Finish: Two finish coats over primer.

3.7.7.5.1. Finish Coats: Full-gloss polyamide epoxy enamel; total dry film thickness of not less than 4 mils.

3.7.8. Ferrous Metal:

3.7.8.1. Provide the indicated "Professional" or "Industrial" coating systems over factory-primed ferrous metal:

3.7.8.2. Low-Luster, Acrylic-Enamel Finish: Two finish coats over a factory-applied primer, or indicated primer as applicable.

3.7.8.2.1. Primer (for factory-unprimed work): Waterborne, rust-inhibitive, acrylic primer; total dry film thickness of not less than 2.0 mils.

3.7.8.2.2. Finish Coats: Low-luster (eggshell), acrylic-latex, interior enamel; total dry film thickness of not less than 2.6 mils.

3.7.8.3. Semigloss, Acrylic-Enamel Finish: Two finish coats over a factory-applied primer, or indicated primer as applicable.

3.7.8.3.1. Primer (for factory-unprimed work): Waterborne, rust-inhibitive, acrylic primer; total dry film thickness of not less than 2.0 mils.

3.7.8.3.2. Finish Coats: Semi-gloss, acrylic-latex, interior enamel; total dry film thickness of not less than 2.0 mils.

3.7.8.4. Epoxy Finish: Two finish coats over a factory-applied primer coat, or indicated primer as applicable.

3.7.8.4.1. Primer for Factory-Unprimed Metals: Waterborne acrylic epoxy primer; total dry film thickness of not less than 2 mils.

3.7.8.4.2. Finish Coats: Full-gloss acrylic epoxy; total dry film thickness of not less than 2.0 mils.

3.7.9. Zinc-Coated Metal:

3.7.9.1. Provide the indicated "Professional" or "Industrial" coating systems over zinc-coated metal:

3.7.9.2. Low-Luster, Acrylic-Enamel Finish: Two finish coats over a factory-applied primer, or indicated primer as applicable.

3.7.9.2.1. Primer (for factory-unprimed work): Quick-drying, rust-inhibitive, acrylic-enamel primer; total dry film thickness of not less than 1.8 mils.

3.7.9.2.2. Second and Third Coats: Low-luster (eggshell), acrylic-latex, interior enamel; total dry film thickness of not less than 2.6 mils.

3.7.9.3. Semigloss, Acrylic-Enamel Finish: Two finish coats over a factory-applied primer, or indicated primer as applicable.

3.7.9.3.1. Primer (for factory-unprimed work): Quick-drying, rust-inhibitive, alkyd-based primer; total dry film thickness of not less than 1.8 mils.

3.7.9.3.2. Second and Third Coats: Semi-gloss, acrylic-latex, interior enamel; total dry film thickness of not less than 2.0 mils.

3.7.9.4. Epoxy Finish: Two finish coats over a factory-applied primer coat, or indicated primer as applicable.

3.7.9.4.1. Primer (for factory-unprimed zinc-coated metal): Waterborne acrylic epoxy primer; total dry film thickness of not less than 4 mils.

3.7.9.4.2. Finish Coats: Full-gloss acrylic epoxy; total dry film thickness of not less than 3.0 mils.

3.8. **EXTERIOR PAINT**

3.8.1. Exterior Paint Systems, General: Products of Benjamin Moore are listed below, unless otherwise indicated. Provide indicated products or, subject to compliance with requirements, equivalent products of other approved manufacturers. Apply coatings at manufacturer's recommended spreading rate to achieve indicated dry film thicknesses.

3.8.2. Where "Industrial" coating is indicated, provide Moore's "Industrial and Maintenance Coatings" products; or equivalent of other, listed approved manufacturers.

3.8.3. Where "Professional" coating is indicated, provide Moore's "Professional Coatings" products; or equivalent of other, listed approved manufacturers.

3.8.4. Concrete and Cement Plaster (for Non-Wear Surfaces):

3.8.5. Provide the indicated "Professional" coating systems over exterior concrete, cement plaster surfaces:

3.8.5.1. Flat Alkyd-Modified Vinyl Acrylic Latex Finish: Two finish coats over a primer.

3.8.5.1.1. Primer: Alkali-resistant, exterior, acrylic-latex sealer; total dry film thickness of not less than 0.7 mils.

3.8.5.1.2. Finish Coats: Flat, exterior, alkyd modified vinyl acrylic latex paint; total dry film thickness of not less than 2.4 mils.

3.8.6. Concrete Masonry Units:

3.8.6.1. Provide the indicated "Professional" coating systems over exterior concrete masonry units:

3.8.6.2. Flat Latex Based Finish: Two finish coats over a block filler.

3.8.6.2.1. Block Filler: High-performance, latex block filler; total dry mill thickness of not less than 8.1 mils.

3.8.6.2.2. Finish Coats: Flat, exterior, acrylic-latex paint; total dry film thickness of not less than 2.4 mils.

3.8.7. Ferrous Metal:

3.8.7.1. Provide the indicated "Professional" or "Industrial" coating systems over exterior ferrous metal.

3.8.7.2. Low Luster, Alkyd-Enamel Finish: Two finish coats over a factory-applied primer, or an alkyd primer as applicable.

3.8.7.2.1. Primer (unprimed work only): Quick-drying, rust-inhibitive, alkyd-based primer, as recommended by the manufacturer for this substrate; total dry film thickness of not less than 1.3 mils.

3.8.7.2.2. Finish Coats: Semigloss, alkyd, exterior enamel; total dry film thickness of not less than 2.6 mils.

3.8.7.3. High Gloss, Alkyd-Enamel Finish: Two finish coats over a factory-applied primer, or an alkyd primer as applicable.

3.8.7.3.1. Primer (unprimed work only): Quick-drying, rust-inhibitive, alkyd-based primer, as recommended by the manufacturer for this substrate; total dry film thickness of not less than 1.3 mils.

3.8.7.3.2. Finish Coats: High gloss, alkyd, exterior enamel; total dry film thickness of not less than 3.4 mils.

3.8.7.4. Polyurethane Finish: Two finish coats over an alkyd primer.

3.8.7.4.1. Primer: Alkyd primer formulated with a rust-inhibiting agent; total dry film thickness of not less than 2.0 mils.

3.8.7.4.2. First and Second Coats: High gloss urethane alkyd enamel; total dry film thickness of not less than 4.0 mils.

3.8.8. Zinc-Coated Metal:

3.8.8.1. Provide the indicated "Professional" or "Industrial" coating systems over exterior zinc-coated (galvanized) metal surfaces:

3.8.8.2. Low Luster, Alkyd-Enamel Finish: Two finish coats over a factory-applied primer, or a galvanized metal primer as applicable.

3.8.8.2.1. Primer (unprimed work only): Quick-drying, rust-inhibitive, alkyd-based primer, as recommended by the manufacturer for this substrate; total dry film thickness of not less than 1.3 mils.

3.8.8.2.2. Finish Coats: Low luster, alkyd, exterior enamel; total dry film thickness of not less than 2.6 mils.

3.8.8.3. High Gloss, Alkyd-Enamel Finish: Two finish coats over a factory-applied primer, or a galvanized metal primer as applicable.

3.8.8.3.1. Primer (for factory-unprimed work): Quick-drying, rust-inhibitive, alkyd-based primer; total dry film thickness of not less than 1.6 mils.

3.8.8.3.2. Second and Third Coats: High gloss, exterior, alkyd enamel; total dry film thickness of not less than 3.4 mils.

3.8.8.4. Polyurethane Finish: Two finish coats over a acrylate primer.

3.8.8.4.1. Primer: Elastomeric acrylate primer formulated with a rust-inhibiting agent; total dry film thickness of not less than 0.1 mils.

3.8.8.4.2. First and Second Finish Coats: High gloss urethane alkyd enamel; total dry film thickness of not less than 4.0 mils.

3.8.9. Aluminum:

3.8.9.1. Provide the indicated "Industrial" coating system over exterior aluminum surfaces:

3.8.9.2. Polyurethane Finish: Two finish coats over a acrylate primer.

3.8.9.2.1. Primer: Elastomeric acrylate primer formulated with a rust-inhibiting agent; total dry film thickness of not less than 0.1 mils.

3.8.9.2.2. Finish Coats: High gloss urethane alkyd enamel; total dry film thickness of not less than 4.0 mils.

3.8.9.3. Acrylic Finish: Two direct to metal coats over appropriately prepared surface.

3.8.9.3.1. Surface preparation: Cleaned with Super Spec HP Oil & Grease Emulsifier (P83) to remove contaminants.

3.8.9.3.2. Direct to metal primer and finish Coats: Low luster direct to metal acrylic; total dry film thickness of not less than 4.0 mils.

3.9. **PROTECTION CLEAN UP, AND TOUCH-UP:**

3.9.1. Protect work from paint droppings and spattering by use of masking, drop cloths, removal of items or by other approved methods.

3.9.2. Upon completion, clean paint from hardware, glass and other surfaces and items not required to be painted of paint drops or smears.

3.9.3. Before final inspection, touch-up or refinished in a manner to produce solid even color and finish texture, free from defects in work which was damaged or discolored.

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1.2.2. Option or optional: Contractor's choice of an alternate material or method.

1.3. RELATED WORK

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1.3.2. Section: 22 05 53 Identification for Plumbing Piping and Equipment.

1.3.3. Section: 23 05 13 Common Motor Requirements for HVAC Equipment.

1.3.4. Section: 23 05 48 Vibration and Seismic Controls for HVAC.

1.3.5. Section: 23 05 93 Testing, Adjusting and Balancing For HVAC.

1.3.6. Section: 23 07 00 HVAC Insulation.

1.4. QUALITY ASSURANCE

1.4.1. Mechanical, electrical and associated systems shall be safe, reliable, efficient, durable, easily and safely operable and maintainable, easily and safely accessible, and in compliance with applicable codes as specified. The systems shall be comprised of high quality institutional-class and industrial-class products of manufacturers that are experienced specialists in the required product lines. All construction firms and personnel shall be experienced and qualified specialists in industrial and institutional HVAC.

1.5. PRODUCTS CRITERIA

1.5.1. Standard Products: Material and equipment shall be the standard products of a manufacturer regularly engaged in the manufacture of the products for at least 3 years (or longer as specified elsewhere). The design, model and size of each item shall have been in satisfactory and efficient operation on at least three installations for approximately three years. However, digital electronics devices, software and systems such as controls, instruments, computer work station, shall be the current generation of technology and basic design that has a proven satisfactory service record of at least three years. See other specification sections for any exceptions and/or additional requirements.

1.5.2. All items furnished shall be free from defects that would adversely affect the performance, maintainability and appearance of individual components and overall assembly.

1.5.3. Conform to codes and standards as required by the specifications. Conform to local codes, if required by local authorities such as the natural gas supplier, if the local codes are more stringent than those specified. Refer any conflicts to the Consultant.

1.5.4. Multiple Units: When two or more units of materials or equipment of the same type or class are required, these units shall be products of one manufacturer.

1.5.5. Assembled Units: Manufacturers of equipment assemblies, which use components made by others, assume complete responsibility for the final assembled product.

1.5.6. Nameplates: Nameplate bearing manufacturer's name or identifiable trademark shall be securely affixed in a conspicuous place on equipment, or name or trademark cast integrally with equipment, stamped or otherwise permanently marked on each item of equipment.

1.5.7. Asbestos products or equipment or materials containing asbestos shall not be used.

1.6. **EQUIPMENT SERVICE ORGANIZATIONS**

1.6.1. HVAC: Products and systems shall be supported by service organizations that maintain a complete inventory of repair parts and are located within 50 miles to the site.

1.6.2. HVAC Mechanical Systems Welding: Before any welding is performed, contractor shall submit a certificate certifying that welders comply with the following requirements:

1.6.2.1. Qualify welding processes and operators for piping according to ASME "Boiler and Pressure Vessel Code", Section IX, "Welding and Brazing Qualifications".

1.6.2.2. Comply with provisions of ASME B31 series "Code for Pressure Piping".

1.7. **EXECUTION (INSTALLATION, CONSTRUCTION) QUALITY**

1.7.1. Apply and install all items in accordance with manufacturer's written instructions. Refer conflicts between the manufacturer's instructions and the contract drawings and specifications to the Consultant for resolution.

1.7.2. Provide complete layout drawings, schematics, diagrams, sections, notes and specifications as required to allow for competitive bidding and construction. Do not commence construction work on any system until the layout drawings have been approved.

1.8. **DUTIES OF MECHANICAL CONTRACTOR**

1.8.1. The mechanical contractor shall assume the responsibilities and duties of a general contractor including but not limited to the ones described below:

1.8.1.1. Superintendence

1.8.1.1.1. Provide full time on-site superintendent personnel and supporting staff with proven experience in project of similar value and complexity.

1.8.1.1.2. Site superintendent shall have over-all authority to speak for and represent the mechanical contractor.

1.8.1.2. Coordination

1.8.1.2.1. Coordinate the work with all the sub-trades involved to ensure that the work will be carried out on schedule and in proper sequence.

1.8.1.2.2. Take complete responsibility for all remedial work that results from failure to coordinate any aspect of the mechanical work prior to its fabrication and/or installation.

1.8.1.2.3. Take responsibility for the delivery of equipment necessary to complete the work in accordance with the approved schedule.

1.8.1.3. Staffing and Scheduling

1.8.1.3.1. Within seven days after the award of the contract, the Mechanical Contractor shall provide to the Board representative the following information:

- Appointment of official representatives in the project.
- Schedule of work.
- Delivery schedule for specified equipment.
- Requirements for temporary facilities, site signs, storage, etc.

1.8.1.4. Work Completion Meeting

1.8.1.4.1. Prior to application for Substantial Performance of the Work, the mechanical contractor shall participate in the take-over meeting. Agenda to include the following:

- Review of outstanding deficiencies.
- Submission of maintenance manuals, warranties and as-built drawings.
- Results of performance tests and described further in this section.
- Scheduling of training to Board's personnel.

1.9. **COMMISSIONING**

1.9.1. The Board may at its discretion use a third party as a commissioning agent for the construction portion of the work. The requirement for commissioning shall be included in the front-end documents of the bidders' package.

1.9.2. If commissioning is included, the contractor shall provide all manpower and will take into account all the hours required to participate in the commissioning process including

meetings with the commissioning agent, completion of forms and check-lists, verifications, simulations, rectifications of deficiencies and other activities associated with the commissioning process.

1.10. **SCHEDULING OF WORK**

1.10.1. For all work to be performed under this contract, adhere to Construction Schedule agreed upon with the Board.

1.11. **INTENT**

1.11.1. Bidders for this work shall include for all labor, material, equipment and all other related cost including all applicable taxes (except HST) and fees to provide the work as indicated on the drawings.

1.11.2. Misinterpretation of any requirement of the drawings and specifications will not relieve the Mechanical Contractor of responsibility. If in any doubt, the Mechanical Contractor shall contact the Consultant for written clarification prior to submitting a bid for the Work.

1.11.3. The scope of work for this project includes but is not limited to:

1.11.3.1. Demolition work

1.11.3.1.1. Refer to Section 02-41-00 for demolition scope of work.

1.11.3.2. New Layout Work

1.11.3.2.1. Provide new rooftop units as indicated on the drawings. Provide all new roof curb, minimum 18" high. Include for all associated roofing and structural work.

1.11.3.2.2. Provide new ductwork in the Cafeteria & Kitchen approximately as indicated on the drawings. Connect new ductwork to new RTU's on roof above. Connect to existing approximately as indicated (where applicable). Insulate all new supply ductwork in the mechanical attic space.

1.11.3.2.3. Allow for temporary removal of the drywall ceiling in the Kitchen area as required to install the new ductwork. Remove existing lights and other devices attached to the ceiling as required to complete the new installation.

1.11.3.2.4. Provide structural steel reinforcement as per the structural drawings. Remove all services attached the OWSJ as required to complete the steel work. Reinstall back on to OWSJ upon completion.

1.11.3.2.5. Provide air balancing for new HVAC equipment to the values noted.

1.11.3.2.6. Provide duct cleaning for ductwork associated with new rooftop units.

1.11.3.2.7. Provide new liquid propane gas lines for new RTUs. Connect to existing on the Cafeteria roof, complete with new PRVs. Paint all new gas piping.

1.11.3.2.8. Paint all new exposed ductwork in the Cafeteria to match existing roof deck colour.

1.11.3.2.9. Provide new power and control connections for new equipment. Include for all required wiring, conduit, and support.

1.12. **INTERFERENCES**

1.12.1. The mechanical drawings do not show all the architectural and structural details, and any information involving accurate measuring of the building shall be taken from the building drawings or at the building. Make without additional change, any necessary changes or additions to the runs of drains, pipes, ducts, etc., to accommodate the above conditions. The location of equipment may be altered without charge providing the change is made before installation and does not necessitate major additional material.

1.12.2. Wherever differences occur between specifications, riser diagrams or schematics and drawings, the maximum conditions shall govern and the bid shall be based on whichever information indicates the greater cost.

1.12.3. Field verifications of dimensions on plans shall be made since actual locations, distances, and levels will be governed by actual field conditions.

1.12.4. Discrepancies between different plans, or between plans and actual field conditions, or between plans and specifications shall promptly be brought to the attention of the Consultant for a decision.

1.12.5. Install all mechanical services including but not exclusive to drains, pipes, and ducts, to conserve headroom and interfere as little as possible with the free use of the space through which they pass. All drains, pipes, ducts, etc., particularly those which may interfere with the inside treatment of the building, or conflicting with other trades, shall be installed only after the locations have been approved by the Consultant. Special care shall be taken in the installation of all mechanical services including, but not exclusive to drains, pipes, and ducts, which are to be concealed, to see that they come within the finished lines of floors, walls, and ceilings. Where such drains, pipes, ducts, etc., have been installed in such a manner as to cause interference, they shall be removed and re installed in suitable locations without extra cost to the Board.

1.12.6. Before commencing work, check and verify all grade and invert elevations, stacks, levels, and dimensions, to ensure proper and correct installation of the work.

1.12.7. In every place where there is space indicated as reserved for future or other equipment, leave such space clear, install blank offs, shut off valves with blind flanges and other work so that the necessary connections can be made without any stoppages to the system. Consult with the consultant whenever necessary for this purpose.

1.12.8. In addition to the work specifically mentioned in the Specifications and shown on the drawings, provide all other items that are obviously necessary to make a complete

working installation, including those required by the Authorities Having Jurisdiction over the work.

1.12.9. The mechanical plans show approximate locations for wall mounted devices. Obtain Consultant's approval of mounting heights and locations before commencement of work.

1.13. **EXAMINE SITE**

1.13.1. Examine the site and the local conditions affecting the work prior to submission of the tender price. Examine carefully all drawings and the complete specifications to ensure that the work can be satisfactorily carried out as shown. No allowance will be made later for any expenses incurred through the failure to make these examinations or to report any such discrepancies in writing to the Consultant.

1.14. **INTERFERENCE AND SLEEVING DRAWINGS**

1.14.1. Submit complete consolidated and coordinated interference drawings for all new air handling systems, and for existing systems that are in the same areas.

1.14.2. The drawings shall include plan views, elevations and sections of all systems and shall be on a scale of not less than 1:200. Clearly identify and dimension the proposed locations of the principal items of equipment. The drawings shall clearly show locations and adequate clearance for all equipment, ductwork, piping, valves, control panels and other items. Show the access means for all items requiring access for operations and maintenance. Provide detailed layout drawings of all piping and duct systems.

1.14.3. Do not install equipment foundations, equipment, ductwork or piping until interference drawings have been approved.

1.15. **WARRANTY**

1.15.1. All work completed under this contract shall carry a min. 1 years' warranty (labour and material) from the date of substantial completion.

1.15.2. **All equipment supplied under this contract shall carry a 2 years' warranty**. Where certain equipment specifications call for a for a longer warranty on certain components, the longest period shall apply.

1.16. **SUBMITTALS**

1.16.1. Submit documentation in accordance with Section: 01 33 23 Shop Drawings, Product Data, and Samples, and with requirements in the individual specification sections.

1.16.2. Contractor shall make all necessary field measurements and investigations to assure that the equipment and assemblies will meet contract requirements.

1.16.3. If equipment is submitted which differs in arrangement from that shown, provide drawings that show the rearrangement of all associated systems. Approval will be given only if all features of the equipment and associated systems, including accessibility, are equivalent to that required by the contract.

1.16.4. Prior to submitting shop drawings for approval, contractor shall certify in writing that manufacturers of all major items of equipment have each reviewed drawings and specifications, and have jointly coordinated and properly integrated their equipment and controls to provide a complete and efficient installation.

1.16.5. Submittals and shop drawings for interdependent items, containing applicable descriptive information, shall be furnished together and complete in a group. Coordinate and properly integrate materials and equipment in each group to provide a completely compatible and efficient.

1.16.6. Manufacturer's Literature and Data:

1.16.6.1. Submit all information pertaining to the performance and capacity of the equipment.

1.16.6.2. Submit all information pertaining to methods of connection to piping and ductwork, electrical wiring, controls and noise generated by the equipment (as applicable to the project).

1.16.6.3. Submit belt drive with the driven equipment. Submit selection data for specific drives when requested by the Consultant.

1.16.6.4. Submit electric motor data and variable speed drive data with the driven equipment.

1.16.6.5. Equipment and materials identification.

1.16.6.6. Fire-stopping materials.

1.16.6.7. Hangers, inserts, supports and bracing, for both indoor and outdoor installations. Where applicable, provide load ratings and deflection for spring supports and hangers.

1.16.6.8. Wall, floor, and ceiling plates.

1.16.7. HVAC Maintenance Data and Operating Instructions:

1.16.7.1. Provide a listing of recommended replacement parts for keeping in stock supply, including sources of supply, for equipment. Include in the listing belts for equipment: Belt manufacturer, model number, size and style, and distinguished whether of multiple belt sets.

1.16.7.2. Provide copies of approved HVAC equipment submittals to the Testing, Adjusting and Balancing Subcontractor.

1.17. **MATERIALS AND STANDARDS OF ACCEPTANCE**

1.17.1. Where materials, equipment, apparatus, or other products are specified by the manufacturer, brand name, type or catalogue number, such designation is to establish standards of desired quality style or dimensions and shall be the basis of the Bid. Materials so specified shall be furnished under this Contract.

1.17.2. Where two or more designations are listed, the contractor shall choose one of those listed and state the choice made on the Bid Form (where applicable). *Note that the basis of design equipment has specific physical characteristics in terms of footprint and clearances requirements. Inclusion of a manufacturer other than the one for the Basis of Design in the Standard of Acceptance is not an automatic approval for submission of equipment which cannot be installed due to specific site conditions.*

1.18. **MATERIAL SUBSTITUTIONS**

1.18.1. After execution of the Contract, requests for substitution of materials or makes other than those specifically named in the Contract Documents may be reviewed and approved by the Consultant, subject to Board's review and acceptance of the financial credits involved.

1.18.2. In the absence of such express approval by the Consultant, the Mechanical Contractor will be held to furnish specified items under the base bid as the standard of acceptance.

1.18.3. If equipment is submitted which differs in arrangement from that specified/shown on the documents, provide drawings that show the rearrangement of all associated systems. Approval will be given only if all features of the equipment and associated systems, including accessibility, are equivalent to that required by the contract.

1.19. **CODES, PERMITS, FEES AND CONNECTIONS**

1.19.1. Conform to Federal, Provincial and Municipal regulations and perform work in accordance with requirements of By Laws and Regulations in force in area where the building is to be erected.

1.19.2. Apply for, obtain, and pay for all permits, fees and service connections for the work and the inspections required by Authorities Having Jurisdiction in the area where the work will take place

1.19.3. Where applicable, apply for, obtain, and pay for all permits, fees and service connections for the work and the inspections required by Authorities Having Jurisdiction in the area where the work will take place, including TSSA and ESA. Where applicable, have the work inspected and certified by PV [Boilers and Pressure Vessels Reg], OE [Operating Engineers Reg.] and FS [Fuel Safety Reg.] branches of TSSA. At the end of the work, the new plant shall be fully TSSA certified.

1.19.4. For information, a specific code or standard might be mentioned. This information must not be taken as the only code or standard applicable.

1.19.5. When part of equipment does not bear the required CSA label, the contractor shall obtain from CSA or Hydro Electric Power Commission, when that part of the equipment is an electric component, a special approval and pay the applicable fees.

1.19.6. Furnish necessary certificates as evidence that the work installed conforms with laws and regulations of Authorities having jurisdiction. Changes in work requested by an Authority having jurisdiction shall be carried out without charge.

1.20. **CONSULTANT'S INSTRUCTIONS**

1.20.1. During construction the Consultant will issue such instructions as may be necessary for verification and correction of the work. These instructions shall be binding as part of the specification.

1.21. **ADDITIONAL WORK AND CHANGES**

1.21.1. Unless a written order, reviewed by the Consultant and countersigned or otherwise approved by the Board Representative, no additional work shall be undertaken by the Contractor.

1.22. **DELIVERY, STORAGE AND HANDLING**

1.22.1. Protection of Equipment:

1.22.1.1. Equipment and material placed on the job site shall remain in the custody of the Contractor until phased acceptance, whether or not the Board has reimbursed the Contractor for the equipment and material. The Contractor is solely responsible for the protection of such equipment and material against any damage.

1.22.1.2. Place damaged equipment in first class, new operating condition; or, replace same as determined and directed by the Consultant. Such repair or replacement shall be at no additional cost to the Board.

1.22.1.3. Protect interiors of new equipment and piping systems against entry of foreign matter. Clean both inside and outside before painting or placing equipment in operation.

1.22.1.4. Existing equipment and piping being worked on by the Contractor shall be under the custody and responsibility of the Contractor and shall be protected as required for new work.

1.22.2. Cleanliness of Piping and Equipment Systems:

1.22.2.1. Exercise care in storage and handling of equipment and piping material to be incorporated in the work. Remove debris arising from cutting, threading and welding of piping.

1.22.2.2. Piping systems shall be flushed, blown or pigged as necessary to deliver clean systems.

1.22.2.3. Clean interior of all tanks prior to delivery for beneficial use by the Board.

1.22.2.4. Boilers shall be left clean following final internal inspection by Board insurance representative or inspector.

1.22.2.5. Contractor shall be fully responsible for all costs, damage, and delay arising from failure to provide clean systems.

1.23. **HAULING OPERATIONS**

1.23.1. Maintain roadways and paving in the hauling areas clean on a daily basis and as required by Municipal Authorities.

1.23.2. Parking is not ample or readily available in the area where the building is located. Coordinate delivery of equipment with the Board representatives.

1.23.3. Contractor is responsible for all craning & lifting operations. It is the Contractor's responsibility to coordinate with the respective Municipality & pay/obtain all required permits.

1.23.4. Contractor is responsible for providing a craning plan for review & approval by the Client.

1.24. **JOB CONDITIONS – WORK IN EXISTING BUILDING**

1.24.1. Building Operation: Board employees will be continuously operating and managing all facilities, including temporary facilities, that serve the building.

1.24.2. Maintenance of Service: Schedule all work to permit continuous service as required by the Board.

1.24.3. Services Interruptions: Limited service interruptions, as required for interconnections of new and existing systems, will be coordinated with the Board and permitted by the Board during the agreed-upon schedule of interruption. Provide at least one week advance notice to the Board representatives.

1.24.4. Phasing of Work: Comply with all requirements shown on drawings or specified.

1.24.5. Building Working Environment: Maintain the architectural and structural integrity of the building and the working environment at all times. Maintain the interior of building at 18 degrees C (65 degrees F) minimum. Limit the opening of doors, windows or other access openings to brief periods as necessary for rigging purposes. No storm water or ground water leakage permitted. Provide daily clean up of construction and demolition debris on all floor surfaces and on all equipment being operated by the Board.

1.24.6. Acceptance of Work for Board Operation: As new facilities are made available for operation and these facilities are of beneficial use to the Board, inspections will be made and tests will be performed. Based on the inspections, a list of contract deficiencies will be issued to the Contractor. After correction of deficiencies as necessary for beneficial use, the Consultant will process necessary acceptance and the equipment will then be under the control and operation of Board personnel.

PART 2 - PRODUCTS

2.1. **FACTORY-ASSEMBLED PRODUCTS**

2.1.1. Provide maximum standardization of components to reduce spare part requirements.

2.1.2. Manufacturers of equipment assemblies that include components made by others shall assume complete responsibility for final assembled unit.

2.1.3. All components of an assembled unit need not be products of same manufacturer.

2.1.4. Constituent parts that are alike shall be products of a single manufacturer.

2.1.5. Components shall be compatible with each other and with the total assembly for intended service.

2.1.6. Contractor shall guarantee performance of assemblies of components, and shall repair or replace elements of the assemblies as required to deliver specified performance of the complete assembly.

2.1.7. Components of equipment shall bear manufacturer's name and trademark, model number, serial number and performance data on a name plate securely affixed in a conspicuous place, or cast integral with, stamped or otherwise permanently marked upon the components of the equipment.

2.1.8. Major items of equipment, which serve the same function, must be the same make and model. Exceptions will be permitted if performance requirements cannot be met.

2.2. **COMPATIBILITY OF RELATED EQUIPMENT**

2.2.1. Equipment and materials installed shall be compatible in all respects with other items being furnished and with existing items so that the result will be a complete and fully operational plant that conforms to contract requirements.

2.3. **BELT DRIVES**

2.3.1. Type: ANSI/RMA standard V belts with proper motor pulley and driven sheave. Belts shall be constructed of reinforced cord and rubber.

2.3.2. Dimensions, rating and selection standards: ANSI/RMA IP 20 and IP 21.

2.3.3. Minimum Horsepower Rating: Motor horsepower plus recommended ANSI/RMA service factor (not less than 20 percent) in addition to the ANSI/RMA allowances for pitch diameter, center distance, and arc of contact.

2.3.4. Maximum Speed: 25 m/s (5000 feet per minute).

2.3.5. Adjustment Provisions: For alignment and ANSI/RMA standard allowances for installation and take up.

2.3.6. Drives may utilize a single V Belt (any cross section) when it is the manufacturer's standard.

2.3.7. Multiple Belts: Matched to ANSI/RMA specified limits by measurement on a belt measuring fixture. Seal matched sets together to prevent mixing or partial loss of sets. Replacement, when necessary, shall be an entire set of new matched belts.

2.3.8. Sheaves and Pulleys:

2.3.8.1. Material: Pressed steel, or close grained cast iron.
2.3.8.2. Bore: Fixed or bushing type for securing to shaft with keys.
2.3.8.3. Balanced: Statically and dynamically.
2.3.8.4. roove spacing for driving and driven pulleys shall be the same.
2.3.8.5. Drive Types, Based on ARI 435.

2.3.9. Provide adjustable pitch or fixed pitch drive as follows:

2.3.9.1. Fan speeds up to 1800 RPM: 7.5 kW (10 horsepower) and smaller.
2.3.9.2. Fan speeds over 1800 RPM: 2.2 kW (3 horsepower) and smaller.
2.3.9.3. Provide fixed pitch drives for drives larger than those listed above.

2.3.10. The final fan speeds required to just meet the system CFM and pressure requirements, without throttling, shall be determined by adjustment of a temporary adjustable pitch motor sheave or by fan law calculation if a fixed pitch drive is used initially.

2.4. **DRIVE GUARDS**

2.4.1. For machinery and equipment, provide guards as shown in AMCA 410 for belts, chains, couplings, pulleys, sheaves, shafts, gears and other moving parts regardless of height above the floor to prevent damage to equipment and injury to personnel. Drive guards may be excluded where motors and drives are inside factory fabricated air handling unit casings.

2.4.2. Pump shafts and couplings shall be fully guarded by a sheet steel guard, covering coupling and shaft but not bearings. Material shall be minimum 16-gage sheet steel; ends shall be

braked and drilled and attached to pump base with minimum of four 6 mm (1/4-inch) bolts. Reinforce guard as necessary to prevent side play forcing guard onto couplings.

2.4.3. V-belt and sheave assemblies shall be totally enclosed, firmly mounted, non-resonant. Guard shall be an assembly of minimum 22-gage sheet steel and expanded or perforated metal to permit observation of belts. 25 mm (one-inch) diameter hole shall be provided at each shaft centerline to permit speed measurement.

2.4.4. Materials: Sheet steel, cast iron, expanded metal or wire mesh rigidly secured so as to be removable without disassembling pipe, duct, or electrical connections to equipment.

2.4.5. Access for Speed Measurement: 25 mm (One inch) diameter hole at each shaft center.

2.5. **LIFTING ATTACHMENTS**

2.5.1. Provide equipment with suitable lifting attachments to enable equipment to be lifted in its normal position. Lifting attachments shall withstand any handling conditions that might be encountered, without bending or distortion of shape, such as rapid lowering and braking of load.

2.6. **EQUIPMENT REQUIREMENTS AND INSTALLATION**

2.6.1. Permit equipment maintenance and disassembly by use of unions or flanges to minimize disturbance to connecting piping and duct systems and without interference from building structure or other equipment.

2.6.2. Provide accessible means for lubricating equipment including permanent lubricated bearings.

2.6.3. For all base mounted boilers, pumps, compressors, air handling units, fans and other rotating equipment, provide chamfered edge housekeeping pads a minimum of 4" high and 4" larger than equipment dimensions all around. Work shall be performed by the trades specializing in this work.

2.6.4. Pipe drain lines, overflows and safety relief vents to drains. If the horizontal drains present a tripping hazard, use aluminum checkered plate covers.

2.6.5. Line up equipment, rectangular cleanouts and similar items with building walls wherever possible.

2.7. **ELECTRIC MOTORS**

2.7.1. All material and equipment furnished and installation methods shall conform to the requirements of Section: 23 05 13 Common Motor Requirements for HVAC Equipment, and Section: 26 05 19 Low-Voltage Electrical Power Conductors and Cables, Provide all electrical wiring, conduit, and devices necessary for the proper connection, protection

and operation of the systems. Provide special energy efficient premium efficiency type motors as scheduled.

2.8. **VARIABLE SPEED MOTOR CONTROLLERS**

2.8.1. Refer to Section: 26 05 00 Common Work Results for Electrical for specifications.

2.8.2. The combination of controller and motor shall be provided by the manufacturer of the driven equipment, such as pumps and fans, and shall be rated for 100 percent output performance. Multiple units of the same class of equipment, i.e. air handlers, fans, pumps, shall be product of a single manufacturer.

2.8.3. Motors shall be premium efficiency type and be approved by the motor controller manufacturer. The controller-motor combination shall be guaranteed to provide full motor nameplate horsepower in variable frequency operation. Both driving and driven motor/fan sheaves shall be fixed pitch.

2.8.4. Controller shall not add any current or voltage transients to the input AC power distribution system, DDC controls, sensitive medical equipment, etc., nor shall be affected from other devices on the AC power system.

2.8.5. Controller shall be provided with the following operating features and accessories:

2.8.5.1. Suitable for variable torque load.

2.8.5.2. Provide thermal magnetic circuit breaker or fused switch with external operator and incoming line fuses. Provide output line reactors on line between drive and motor for motors over 50 HP or where the distance between the breaker and motor exceeds 50 feet.

2.9. **EQUIPMENT AND MATERIALS IDENTIFICATION**

2.9.1. Refer to Section: 23 05 53 Identification for HVAC Piping and Equipment.

2.10. **FIRESTOPPING**

2.10.1. Provide either factory built (Firestop Devices) or field installed (through-Penetration Firestop Systems) to form a specific building system maintaining required integrity of the fire barrier and stop the passage of gases or smoke. Firestop systems to accommodate building movements without impairing their integrity.

2.10.2. Through-penetration firestop systems and firestop devices tested in accordance with ASTM E814 or UL 1479 using the "F" or "T" rating to maintain the same rating and integrity as the fire barrier being sealed. "T" ratings are not required for penetrations smaller than or equal to 101 mm (4 inches) nominal pipe or 0.01 square meter (16 square inches) in overall cross sectional area.

2.10.3. Firestop sealants used for firestopping or smoke sealing to have the following properties:

2.10.3.1. Contain no flammable or toxic solvents.

2.10.3.2. Release no dangerous or flammable out gassing during the drying or curing of products.

2.10.3.3. Water-resistant after drying or curing and unaffected by high humidity, condensation or transient water exposure.

2.10.3.4. When installed in exposed areas, capable of being sanded and finished with similar surface treatments as used on the surrounding wall or floor surface.

2.10.4. Firestopping system or devices used for penetrations by glass pipe, plastic pipe or conduits, unenclosed cables, or other non-metallic materials to have following properties:

2.10.4.1. Classified for use with the particular type of penetrating material used.

2.10.4.2. Penetrations containing loose electrical cables, computer data cables, and communications cables protected using firestopping systems that allow unrestricted cable changes without damage to the seal.

2.10.5. Maximum flame spread of 25 and smoke development of 50 when tested in accordance with ASTM E84 or UL 723. Material to be an approved firestopping material as listed in UL Fire Resistance Directory or by a nationally recognized testing laboratory.

2.10.6. FM, UL, or WH rated or tested by an approved laboratory in accordance with ASTM E814.

2.10.7. Materials to be nontoxic and noncarcinogen at all stages of application or during fire conditions and to not contain hazardous chemicals. Provide firestop material that is free from Ethylene Glycol, PCB, MEK, and asbestos.

2.10.8. For firestopping exposed to view, traffic, moisture, and physical damage, provide products that do not deteriorate when exposed to these conditions.

2.10.8.1. For piping penetrations for plumbing and wet-pipe sprinkler systems, provide moisture-resistant through-penetration firestop systems.

2.10.8.2. For floor penetrations with annular spaces exceeding 101 mm (4 inches) or more in width and exposed to possible loading and traffic, provide firestop systems capable of supporting the floor loads involved either by installing floor plates or by other means acceptable to the firestop manufacturer.

2.10.8.3. For penetrations involving insulated piping, provide through-penetration firestop systems not requiring removal of insulation.

2.11. **GALVANIZED REPAIR COMPOUND**

2.11.1. Mil. Spec. DOD P 21035B, paint form.

2.12. **HVAC PIPE AND EQUIPMENT SUPPORTS AND RESTRAINTS**

2.12.1. Vibration Isolators: Refer to Section: 23 05 48 Vibration and Seismic Controls for HVAC.

2.12.2. Supports for Roof Mounted Items:

2.12.2.1. Equipment: Refer to details on mechanical and structural drawings.
2.12.2.2. Pipe Supports: Refer to details on the drawings.
2.12.2.3. Supports for Indoor Mounted Items

2.12.2.3.1. Attachment to Concrete Building Construction:
- Concrete insert: MSS SP-58, Type 18.
- Self drilling expansion shields and machine bolt expansion anchors: Permitted in concrete not less than 102 mm (four inches) thick when approved by the Consultant for each job condition.
- Power driven fasteners: Permitted in existing concrete or masonry not less than 102 mm (four inches) thick when approved by the Consultant for each job condition.

2.12.2.3.2. Attachment to Steel Building Construction:
- Welded attachment: MSS SP 58, Type 22.
- Beam clamps: MSS SP-58, Types 20, 21, 28 or 29. Type 23 C clamp may be used for individual copper tubing up to 23mm (7/8 inch) outside diameter.

2.12.2.3.3. Attachment to existing structure: Support from existing floor/roof frame
- Attachment to Wood Construction: Wood screws or lag bolts.
- Hanger Rods: Hot rolled steel, ASTM A36 or A575 for allowable load listed in MSS SP 58. For piping, provide adjustment means for controlling level or slope. Types 13 or 15 turn buckles shall provide 38 mm (1 1/2 inches) minimum of adjustment and incorporate locknuts. All thread rods are acceptable.

2.12.2.3.4. Hangers Supporting Multiple Pipes (Trapeze Hangers): Galvanized, cold formed, lipped steel channel horizontal member, not less than 41 mm by 41 mm (1 5/8 inches by 1 5/8 inches), 2.7 mm (No. 12 gage), designed to accept special spring held, hardened steel nuts. Not permitted for steam supply and condensate piping.

2.12.2.3.5. Allowable hanger load: Manufacturers rating less 91kg (200 pounds).

2.12.2.3.6. Guide individual pipes on the horizontal member of every other trapeze hanger with 6 mm (1/4 inch) U bolt fabricated from steel rod. Provide Type 40 insulation shield, secured by two 13mm (1/2 inch) galvanized steel bands, or preinsulated calcium silicate shield for insulated piping at each hanger.

2.12.3. Supports for Piping Systems:

2.12.3.1. Select hangers sized to encircle insulation on insulated piping. Refer to Section 23 07 11 for insulation thickness. To protect insulation, provide Type 39 saddles for roller type supports or pre-insulated calcium silicate shields. Provide Type 40 insulation shield or pre-insulated calcium silicate shield at all other types of supports and hangers including those for pre-insulated piping.

2.12.4. Piping Systems (MSS SP 58):

2.12.4.1. Standard clevis hanger: Type 1; provide locknut.
2.12.4.2. Riser clamps: Type 8.
2.12.4.3. Wall brackets: Types 31, 32 or 33.
2.12.4.4. Roller supports: Type 41, 43, 44 and 46.
2.12.4.5. Saddle support: Type 36, 37 or 38.
2.12.4.6. Turnbuckle: Types 13 or 15. Preinsulate.
2.12.4.7. U bolt clamp: Type 24.

2.12.5. Copper Tube:

2.12.5.1. Hangers, clamps and other support material in contact with tubing shall be painted with copper colored epoxy paint, plastic coated or taped with non-adhesive isolation tape to prevent electrolysis.
2.12.5.2. For vertical runs use epoxy painted or plastic coated riser clamps.
2.12.5.3. For supporting tube to strut: Provide epoxy painted pipe straps for copper tube or plastic inserted vibration isolation clamps.

2.12.6. Insulated Lines: Provide pre-insulated calcium silicate shields sized for copper tube.

2.12.7. Supports for plastic or glass piping: As recommended by the pipe manufacturer with black rubber tape extending one inch beyond steel support or clamp.

2.12.8. Piping with Vertical Expansion and Contraction:

2.12.8.1. Movement up to 20 mm (3/4 inch): Type 51 or 52 variable spring unit with integral turn buckle and load indicator.
2.12.8.2. Movement more than 20 mm (3/4 inch): Type 54 or 55 constant support unit with integral adjusting nut, turn buckle and travel position indicator.
2.12.8.3. Convertor and Expansion Tank Hangers: May be Type 1 sized for the shell diameter. Insulation where required will cover the hangers.

2.12.9. For pipe sizes larger than (50 mm) 2-inches:

2.12.9.1. Pre-insulated Calcium Silicate Shields:
2.12.9.1.1. Provide 360 degree water resistant high density 965 kPa (140 psi) compressive strength calcium silicate shields encased in galvanized metal.

2.12.9.1.2. Pre-insulated calcium silicate shields to be installed at the point of support during erection.

2.12.9.1.3. Shield thickness shall match the pipe insulation.

2.12.9.1.4. The type of shield is selected by the temperature of the pipe, the load it must carry, and the type of support it will be used with.

2.12.9.1.5. Shields for supporting chilled or cold water shall have insulation that extends a minimum of 1 inch past the sheet metal. Provide for an adequate vapor barrier in chilled lines.

2.12.9.1.6. The pre-insulated calcium silicate shield shall support the maximum allowable water filled span as indicated in MSS-SP 69. To support the load, the shields may have one or more of the following features: structural inserts 4138 kPa (600 psi) compressive strength, an extra bottom metal shield, or formed structural steel (ASTM A36) wear plates welded to the bottom sheet metal jacket.

2.12.9.1.7. Shields may be used on steel clevis hanger type supports, roller supports or flat surfaces

2.13. **PIPE PENETRATIONS – ROOFS**

2.13.1. Refer to details on the drawings

2.14. **PIPE PENETRATIONS THROUGH INTERIOR BUILDING ELEMENTS**

2.14.1. Install sleeves during construction for other than blocked out floor openings for risers in mechanical bays.

2.14.2. To prevent accidental liquid spills from passing to a lower level, provide the following:

2.14.2.1. For sleeves: Extend sleeve 25 mm (one inch) above finished floor and provide sealant for watertight joint.

2.14.2.2. For blocked out floor openings: Provide 40 mm (1½ inch) angle set in silicone adhesive around opening.

2.14.2.3. For drilled penetrations: Provide 40 mm (1½ inch) angle ring or square set in silicone adhesive around penetration.

2.14.3. Penetrations are not allowed through beams or ribs, but may be installed in concrete beam flanges. Any deviation from these requirements must receive prior approval of Consultant.

2.14.4. Sheet Metal, Plastic, or Moisture resistant Fiber Sleeves: Provide for pipe passing through floors, interior walls, and partitions, unless brass or steel pipe sleeves are specifically called for below.

2.14.5. Cast Iron or Zinc Coated Pipe Sleeves: Provide for pipe passing through exterior walls below grade. Make space between sleeve and pipe watertight with a modular or link rubber seal. Seal shall be applied at both ends of sleeve.

2.14.6. Galvanized Steel or an alternate Black Iron Pipe with asphalt coating Sleeves: Provide for pipe passing through concrete beam flanges, except where brass pipe sleeves are called for. Provide sleeve for pipe passing through floor of mechanical rooms, laundry work rooms, and animal rooms above basement. Except in mechanical rooms, connect sleeve with floor plate.

2.14.7. Brass Pipe Sleeves: Provide for pipe passing through quarry tile, terrazzo or ceramic tile floors. Connect sleeve with floor plate.

2.14.8. Sleeves are not required for wall hydrants for fire department connections or in drywall construction.

2.14.9. Sleeve Clearance: Sleeve through floors, walls, partitions, and beam flanges shall be one inch greater in diameter than external diameter of pipe. Sleeve for pipe with insulation shall be large enough to accommodate the insulation. Interior openings shall be caulked tight with fire stopping material and sealant to prevent the spread of fire, smoke, and gases.

2.15. **DUCT PENETRATIONS - ROOFS**

2.15.1. Provide curbs for roof mounted piping, ductwork and equipment. Curbs shall be 18 inches high with continuously welded seams, built-in cant strip, interior baffle with acoustic insulation, curb bottom, hinged curb adapter.

2.15.2. Refer to details on mechanical and structural drawings.

2.16. **DUCT PENETRATIONS – INTERIOR BUILDING ELEMENTS**

2.16.1. Provide sheet metal sleeves min 150 mm (6") raised above the penetrated floors. Seal space between sleeves and ducts.

2.16.2. For penetrations through fire rated building elements, refer to details on the drawings.

2.16.3. Provide firestopping for openings through fire and smoke barriers, maintaining minimum required rating of floor, ceiling or wall assembly.

2.17. **SPECIAL TOOLS AND LUBRICANTS**

2.17.1. Furnish, and turn over to the Board, tools not readily available commercially, that are required for disassembly or adjustment of equipment and machinery furnished.

2.17.2. Grease Guns with Attachments for Applicable Fittings: One for each type of grease required for each motor or other equipment.

2.17.3. Refrigerant Tools: Provide system charging/Evacuation equipment, gauges, fittings, and tools required for maintenance of furnished equipment.

2.17.4. Tool Containers: Hardwood or metal, permanently identified for intended service and mounted, or located, where directed by the Consultant.

2.17.5. Lubricants: A minimum of 0.95 L (one quart) of oil, and 0.45 kg (one pound) of grease, of equipment manufacturer's recommended grade and type, in unopened containers and properly identified as to use for each different application.

2.18. **WALL, FLOOR AND CEILING PLATES**

2.18.1. Material and Type: Chrome plated brass or chrome plated steel, one piece or split type with concealed hinge, with set screw for fastening to pipe, or sleeve. Use plates that fit tight around pipes, cover openings around pipes and cover the entire pipe sleeve projection.

2.18.2. Thickness: Not less than 2.4 mm (3/32 inch) for floor plates. For wall and ceiling plates, not less than 0.64 mm (0.025-inch) for up to 80 mm (3 inch pipe), 0.89 mm (0.035-inch) for larger pipe.

2.18.3. Locations: Use where pipe penetrates floors, walls and ceilings in exposed locations, in finished areas only. Provide a watertight joint in spaces where brass or steel pipe sleeves are specified.

PART 3 - EXECUTION

3.1. **ARRANGEMENT AND INSTALLATION OF EQUIPMENT AND PIPING**

3.1.1. Coordinate location of piping, sleeves, inserts, hangers, ductwork and equipment. Locate piping, sleeves, inserts, hangers, ductwork and equipment clear of windows, doors, openings, light outlets, and other services and utilities. Prepare equipment layout drawings to coordinate proper location and personnel access of all facilities. Submit the interference drawings for review as required by Part 1. Follow manufacturer's published recommendations for installation methods not otherwise specified.

3.1.2. Operating Personnel Access and Observation Provisions: Select and arrange all equipment and systems to provide clear view and easy access, without use of portable ladders, for maintenance and operation of all devices including, temperature but not limited to: all equipment items, valves, filters, strainers, transmitters, sensors, control devices. All gages and indicators shall be clearly visible by personnel standing on the floor or on permanent

platforms. Do not reduce or change maintenance and operating space and access provisions that are shown on the drawings.

3.2. **THERMOMETERS AND PRESSURE GAUGES**

3.2.1. General:

3.2.1.1. Locate direct reading thermometers and gauges for reading from floor or platform.

3.2.1.2. Provide remote reading thermometers and gauges where direct reading instruments cannot be satisfactorily located.

3.2.1.3. Locate engraved lamacoid nameplate as specified in Section Identification, identifying medium adjacent to thermometers and gauges.

3.2.2. Thermometers:

3.2.2.1. Industrial, 9" adjustable angle cast aluminum case, CGSB standard CAN/CGSB-14.4-M88 red reading mercury, lens front tube, white scale black embossed figures, clear glass or acrylic window, tapered aluminum stem.

3.2.2.2. Scale shall be suitable for 2 times the temperature range of service. Scale shall be combined Celsius and Fahrenheit.

3.2.2.3. Standard of Acceptance: Weiss, Ashcroft, Trerice.

3.2.3. Pressure Gauges:

3.2.3.1. 5" dial, solid front blow out back, fibreglass reinforced polypropylene case, phosphor bronze bourdon tube and brass 1/4" N.P.T. socket, bottom connection, stainless steel rotary type movement, gauge to be registered with the Provincial Boiler and Pressure Vessel Safety Branch with a registration number and conform to ANSI B40.1. Accuracy to be grade "A".

3.2.3.2. On pumps liquid filled gauges shall be utilized.

3.2.3.3. Standard of Acceptance: Weiss, Ashcroft, Trerice.

3.2.3.4. Provide bronze stop cock, bronze bar stock ¼" N.P.T. bronze porous core pressure snubber for pulsating operation and diaphragm for corrosive service.

3.2.3.5. Use materials compatible with system requirements.

3.2.4. Gauges shall have combined kilopascal and psi scales.

3.3. **EQUIPMENT AND PIPING SUPPORT**

3.3.1. Coordinate structural systems necessary for pipe and equipment support with pipe and equipment locations to permit proper installation.

3.3.2. Location of pipe sleeves, trenches and chases shall be accurately coordinated with equipment and piping locations.

3.3.3. Cutting Holes:

3.3.3.1. Cut holes through concrete and masonry by rotary core drill. Pneumatic hammer, impact electric, and hand or manual hammer type drill will not be allowed, except as permitted by Consultant where working area space is limited.

3.3.3.2. Locate holes to avoid interference with structural members such as beams or grade beams. Holes shall be laid out in advance and drilling done only after approval by Consultant. If the Contractor considers it necessary to drill through structural members, this matter shall be referred to Consultant for approval.

3.3.3.3. Do not penetrate membrane waterproofing.

3.4. **ITEMS NOT SHOWN BUT REQUIRED**

3.4.1. Interconnection of Instrumentation or Control Devices: Generally, electrical and pneumatic interconnections are not shown but must be provided.

3.4.2. Minor Piping: Generally, small diameter pipe runs from drips and drains, water cooling, and other service are not shown but must be provided.

3.4.3. Electrical and Pneumatic Interconnection of Controls and Instruments: This generally not shown but must be provided. This includes interconnections of sensors, transmitters, transducers, control devices, control and instrumentation panels, instruments and computer workstations. Comply with NFPA-70.

3.5. **PROTECTION AND CLEANING**

3.5.1. Equipment and materials shall be carefully handled, properly stored, and adequately protected to prevent damage before and during installation, in accordance with the manufacturer's recommendations and as approved by the Consultant. Damaged or defective items in the opinion of the Consultant, shall be replaced.

3.5.2. Protect all finished parts of equipment, such as shafts and bearings where accessible, from rust prior to operation by means of protective grease coating and wrapping. Close pipe openings with caps or plugs during installation. Tightly cover and protect fixtures and equipment against dirt, water chemical, or mechanical injury. At completion of all work thoroughly clean fixtures, exposed materials and equipment.

3.6. **WORK IN EXISTING BUILDING**

3.6.1. Make alterations to existing service piping at times that will least interfere with normal operation of the facility.

3.6.2. Cut required openings through existing masonry and reinforced concrete using diamond core drills. Use of pneumatic hammer type drills, impact type electric drills, and hand or manual hammer type drills, will be permitted only with approval of the Board. Locate

openings that will least effect structural slabs, columns, ribs or beams. Refer to the Consultant for determination of proper design for openings through structural sections and opening layouts approval, prior to cutting or drilling into structure. After Consultant's approval, carefully cut opening through construction no larger than absolutely necessary for the required installation.

3.6.3. Switchgear/Electrical Equipment Drip Protection: Every effort shall be made to eliminate the installation of pipe above electrical and telephone switchgear. If this is not possible, encase pipe in a second pipe with a minimum of joints. Installation of piping, ductwork, leak protection apparatus or other installations foreign to the electrical installation shall be located in the space equal to the width and depth of the equipment and extending from to a height of 1.8 m (6 ft.) above the equipment to ceiling structure, whichever is lower (NFPA 70).

3.6.4. Inaccessible Equipment:

3.6.4.1. Where the Board determines that the Contractor has installed equipment not conveniently accessible for operation and maintenance, equipment shall be removed and reinstalled or remedial action performed as directed at no additional cost to the Board.

3.6.4.2. The term "conveniently accessible" is defined as capable of being reached without climbing or crawling under or over obstacles such as motors, fans, pumps, belt guards, transformers, high voltage lines, piping, and ductwork.

3.7. **TEMPORARY PIPING AND EQUIPMENT**

3.7.1. Continuity of operation of existing facilities will generally require temporary installation or relocation of equipment and piping.

3.7.2. The Contractor shall provide all required facilities in accordance with the requirements of phased construction and maintenance of service. All piping and equipment shall be properly supported, sloped to drain, operate without excessive stress, and shall be insulated where injury can occur to personnel by contact with operating facilities.

3.7.3. Temporary facilities and piping shall be completely removed and any openings in structures sealed. Provide necessary blind flanges and caps to seal open piping remaining in service.

3.8. **RIGGING**

3.8.1. Design is based on application of available equipment. Openings in building structures are planned to accommodate design scheme.

3.8.2. Alternative methods of equipment delivery may be offered by Contractor and will be considered by Board under specified restrictions of phasing and maintenance of service as well as structural integrity of the building.

3.8.3. Close all openings in the building when not required for rigging operations to maintain proper environment in the facility for Board operation and maintenance of service.

3.8.4. Contractor shall provide all facilities required to deliver specified equipment and place on foundations. Attachments to structures for rigging purposes and support of equipment on structures shall be Contractor's full responsibility. Upon request, the Board will check structure adequacy and advise Contractor of recommended restrictions.

3.8.5. Contractor shall check all clearances, weight limitations and shall offer a rigging plan designed by a Registered Professional Engineer. All modifications to structures, including reinforcement thereof, shall be at Contractor's cost, time and responsibility.

3.8.6. Rigging plan and methods shall be referred to Consultant for evaluation prior to actual work.

3.8.7. Restore building to original condition upon completion of rigging work.

3.9. **PIPE AND EQUIPMENT SUPPORTS**

3.9.1. Where hanger spacing does not correspond with joist or rib spacing, use structural steel channels secured directly to joist and rib structure that will correspond to the required hanger spacing, and then suspend the equipment and piping from the channels. Drill or burn holes in structural steel only with the prior approval of the Consultant.

3.9.2. Use of chain, wire or strap hangers; wood for blocking, stays and bracing; or, hangers suspended from piping above will not be permitted. Replace or thoroughly clean rusty products and paint with zinc primer.

3.9.3. Use hanger rods that are straight and vertical. Turnbuckles for vertical adjustments may be omitted where limited space prevents use. Provide a minimum of 15 mm (1/2 inch) clearance between pipe or piping covering and adjacent work.

3.9.4. HVAC Horizontal Pipe Support Spacing: Refer to MSS SP 69. Provide additional supports at valves, strainers, in line pumps and other heavy components. Provide a support within one foot of each elbow.

3.9.5. HVAC Vertical Pipe Supports:

3.9.5.1. Up to 150 mm (6 inch pipe), 9 m (30 feet) long, bolt riser clamps to the pipe below couplings, or welded to the pipe and rests supports securely on the building structure.

3.9.5.2. Vertical pipe larger than the foregoing, support on base elbows or tees, or substantial pipe legs extending to the building structure.

3.9.6. Overhead Supports:

3.9.6.1. The basic structural system of the building is designed to sustain the loads imposed by equipment and piping to be supported overhead.

3.9.6.2. Provide steel structural members, in addition to those shown, of adequate capability to support the imposed loads, located in accordance with the final approved layout of equipment and piping.

3.9.7. Tubing and capillary systems shall be supported in channel troughs.

3.9.8. Floor Supports:

3.9.8.1. Provide concrete bases, concrete anchor blocks and pedestals, and structural steel systems for support of equipment and piping. Anchor and dowel concrete bases and structural systems to resist forces under operating and seismic conditions (if applicable) without excessive displacement or structural failure.

3.9.8.2. Do not locate or install bases and supports until equipment mounted thereon has been approved. Size bases to match equipment mounted thereon plus 50 mm (2 inch) excess on all edges. Boiler foundations shall have horizontal dimensions that exceed boiler base frame dimensions by at least 150 mm (6 inches) on all sides. Refer to structural drawings. Bases shall be neatly finished and smoothed, shall have chamfered edges at the top, and shall be suitable for painting.

3.9.9. All equipment shall be shimmed, leveled, firmly anchored, and grouted with epoxy grout. Anchor bolts shall be placed in sleeves, anchored to the bases. Fill the annular space between sleeves and bolts with a granular material to permit alignment and realignment.

3.10. **CLEANING AND PAINTING**

3.10.1. Prior to final inspection and acceptance of the plant and facilities for beneficial use by the Board, the plant facilities, equipment and systems shall be thoroughly cleaned and painted.

3.10.2. In addition, the following special conditions apply:

3.10.2.1. Cleaning shall be thorough. Use solvents, cleaning materials and methods recommended by the manufacturers for the specific tasks. Remove all rust prior to painting and from surfaces to remain unpainted. Repair scratches, scuffs, and abrasions prior to applying prime and finish coats.

3.10.3. Material And Equipment Not To Be Painted Includes:

3.10.3.1. Motors, controllers, control switches, and safety switches.
3.10.3.2. Control and interlock devices.
3.10.3.3. Regulators.
3.10.3.4. Pressure reducing valves.
3.10.3.5. Control valves and thermostatic elements.
3.10.3.6. Lubrication devices and grease fittings.
3.10.3.7. Copper, brass, aluminum, stainless steel and bronze surfaces.
3.10.3.8. Valve stems and rotating shafts.
3.10.3.9. Pressure gauges and thermometers.
3.10.3.10. Glass.
3.10.3.11. Name plates.

3.10.4. Control and instrument panels shall be cleaned, damaged surfaces repaired, and shall be touched-up with matching paint obtained from panel manufacturer.

3.10.5. Pumps, motors, steel and cast iron bases, and coupling guards shall be cleaned, and shall be touched-up with the same color as utilized by the pump manufacturer

3.10.6. Temporary Facilities: Apply paint to surfaces that do not have existing finish coats.

3.10.7. Final result shall be smooth, even-colored, even-textured factory finish on all items. Completely repaint the entire piece of equipment if necessary to achieve this.

3.11. **IDENTIFICATION SIGNS**

3.11.1. Refer to Section: 23 05 53 Identification for HVAC Piping and Equipment.

3.12. **MOTOR AND DRIVE ALIGNMENT**

3.12.1. Belt Drive: Set driving and driven shafts parallel and align so that the corresponding grooves are in the same plane.

3.12.2. Direct connect Drive: Securely mount motor in accurate alignment so that shafts are free from both angular and parallel misalignment when both motor and driven machine are operating at normal temperatures.

3.13. **LUBRICATION**

3.13.1. Lubricate all devices requiring lubrication prior to initial operation. Field-check all devices for proper lubrication.

3.13.2. Equip all devices with required lubrication fittings or devices. Provide a minimum of one liter (one quart) of oil and 0.5 kg (one pound) of grease of manufacturer's recommended grade and type for each different application; also provide 12 grease sticks for lubricated

plug valves. Deliver all materials to Consultant in unopened containers that are properly identified as to application.

3.13.3. Provide a separate grease gun with attachments for applicable fittings for each type of grease applied.

3.13.4. All lubrication points shall be accessible without disassembling equipment, except to remove access plates.

3.14. **CONCRETE**

3.14.1. All concrete work required to complete this project, whether shown on the drawings or not, shall be the Contractor's responsibility.

3.14.2. Refer to this specification section for requirements for housekeeping pad.

3.15. **METALS**

3.15.1. All steel construction required for the completion of this project, whether shown on the drawings or not, shall be the Contractor's responsibility.

3.16. **CUTTING, PATCHING, ROOFING, AND X-RAY**

3.16.1. All cutting, patching, roofing and X-Rays required for the completion of this project whether shown on the drawings or not, shall be the Contractor's responsibility. The cutting and patching work shall be performed in accordance with the following:

3.16.1.1. All cutting and patching shall be done by the trades specializing in the materials to be cut.

3.16.1.2. All flashing and equipment supports on the roof shall be done in strict accordance with the Board standards by Board-approved roofing contractors only.

3.16.1.3. Should any cutting, roofing and/or repairing of finished surfaces be required, the Sub-trade contractor for the Contractor shall employ the particular trades engaged on the site for this type of work.

3.16.1.4. None of the roofing work shall affect any current roof warranty. Coordinate with the Board representative the status of the roof, and if under warranty, coordinate all the work with the warranty holder.

3.16.1.5. Supporting members of any floor, wall or the building structure shall be cut only in such a location and manner as approved by the Consultant.

3.16.1.6. Where slabs in the portions of the building which are existing must be saw-cut or core drilled, all locations shall be x-rayed prior to saw-cutting or core-drilling. All x-raying shall be done by personnel qualified in the use of the type of equipment required to x-ray the saw-cuts shall be permitted to perform this work on the site. No allowance will be made later for expenses incurred through the failure of performing these x-rays.

3.17. **OPERATING AND MAINTENANCE MANUALS**

3.17.1. Refer to Section: 01 33 23 Shop Drawings, Product Data, and Samples.

3.18. **CLOSE-OUT DOCUMENTATION**

3.18.1. 10 (ten) days prior to substantial performance of work obtain documentation and/or prepare certification of the following items and submit them to the Board representative:

3.18.1.1. All inspection certificates.
3.18.1.2. Guarantee certificates as called for under "Warranty".
3.18.1.3. Record drawings.
3.18.1.4. Operating and Maintenance Manuals.
3.18.1.5. Test certifications as called for under "Testing".
3.18.1.6. Provide a signed statement to the effect that all tests for mechanical systems and equipment have been completely carried out in the Trade Sections of these Specifications and to the manufacturer's recommendations, and in accordance with the requirements of all authorities having jurisdiction.

3.19. **COMMISSIONING**

3.19.1. Where applicable and the commissioning process is part of the project, provide commissioning documentation and all the manpower required for all inspection, start up, and contractor testing required above and required by the Checklists provided by the Commissioning Agent.

3.19.2. Coordinate with the Commissioning Agent if the start up and operation of the installed equipment is part of larger systems which require additional testing and verification.

3.20. **STARTUP AND TEMPORARY OPERATION**

3.20.1. Startup equipment as described in equipment specifications. Verify that vibration is within specified tolerance prior to extended operation.

3.21. **OPERATING AND PERFORMANCE TESTS**

3.21.1. Prior to the final inspection, perform required tests as specified and submit the test reports and records to the Consultant. The timing of the tests shall be arranged to suit the convenience of the Consultant, and the manner and duration shall be as the Consultant deems necessary. Record the daily start and stop times, operating hours and functions performed. Ensure that the performance tests are witnessed by the Consultant.

3.21.2. Should evidence of malfunction in any tested system, or piece of equipment or component part thereof, occur during or as a result of tests, make proper corrections, repairs or replacements, and repeat tests at no additional cost to the Board.

3.21.3. At the successful completion of Performance Tests and all testing and balancing, make the systems ready for final inspection and subsequent acceptance of the Board. Replace and clean filters, flush out lines and equipment, remove and clean strainers, fill liquid systems and purge air. Provide water treatment to pipes and report in accordance to current by-laws. Disinfect all domestic water as required by current by-laws and Authorities Having Jurisdiction.

3.21.4. When completion of certain work or system occurs at a time when final control settings and adjustments cannot be properly made to make performance tests, then make performance tests for heating systems and for cooling systems respectively during first actual seasonal use of respective systems following completion of work.

3.22. **INSTRUCTIONS TO BOARD PERSONNEL**

3.22.1. Provide in accordance with Section: 01 79 00 Demonstration and Training.

Table of Contents

PART 1 - GENERAL

1.1. **DESCRIPTION**

1.1.1. This section specifies the furnishing, installation and connection of motors for HVAC equipment.

1.2. **RELATED WORK**

1.2.1. Section: 01 33 23 Shop Drawings, Product Data, and Samples.

1.2.2. Section: 23 05 00 Common Work Results for HVAC.

1.2.3. Section: 26 05 00 Common Work Results for Electrical.

1.2.4. Section: 26 05 19 Low-Voltage Electrical Power Conductors and Cables.

1.3. **SUBMITTALS**

1.3.1. Submit in accordance with Section: 01 33 23 Shop Drawings, Product Data, and Samples, and Section: 26 05 00 Common Work Results for Electrical.

1.3.2. Shop Drawings:

1.3.2.1. Provide documentation to demonstrate compliance with drawings and specifications.

1.3.2.2. Include electrical ratings, efficiency, bearing data, power factor, frame size, dimensions, mounting details, materials, horsepower, voltage, phase, speed (RPM), enclosure, starting characteristics, torque characteristics, code letter, full load and locked rotor current, service factor, and lubrication method.

1.3.3. Manuals:

1.3.3.1. Submit simultaneously with the shop drawings, companion copies of complete installation, maintenance and operating manuals, including technical data sheets and application data.

1.3.3.2. Certification: Two weeks prior to final inspection, unless otherwise noted, submit four copies of the following certification to the Resident Engineer:

1.3.3.3. Certification that the motors have been applied, installed, adjusted, lubricated, and tested according to manufacturer published recommendations.

1.4. **APPLICABLE PUBLICATIONS**

1.4.1. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.

1.4.2. National Electrical Manufacturers Association (NEMA):

1.4.2.1. MG 1-2006 Rev. 1 2009 Motors and Generators

1.4.2.2. MG 2–2001Rev. 1 2007 Safety Standard for Construction and Guide for Selection, Installation and Use of Electric Motors and Generators

1.4.3. National Fire Protection Association (NFPA):

1.4.3.1. 70-latest National Electrical Code (NEC)

1.4.4. Institute of Electrical and Electronics Engineers (IEEE):

1.4.4.1. 112-04 Standard Test Procedure for Polyphase Induction Motors and Generators

1.4.5. American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE):

1.4.5.1. 90.1-latest Energy Standard for Buildings Except Low-Rise Residential Buildings

1.5. **STANDARDS OF ACCEPTANCE**

1.5.1. Baldor Electric Company

1.5.2. Leeson Electric

1.5.3. General Electric

1.5.4. Dayton

PART 2 - PRODUCTS

2.1. **MOTORS**

2.1.1. All material and equipment furnished and installation methods shall conform to the requirements of Section 26 29 11, LOW-VOLTAGE MOTOR STARTERS; and Section 26 05 19, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES (600 VOLTS AND BELOW). Provide all electrical wiring, conduit, and devices necessary for the proper connection, protection and operation of the systems. Provide premium efficiency type motors as scheduled. Unless otherwise specified for a particular application, use electric motors with the following requirements.

2.1.2. Single phase Motors: Motors for centrifugal fans and pumps may be split phase or permanent split capacitor (PSC) type. Provide capacitor-start type for hard starting applications.

2.1.3. Electrically Commutated motor (EC Type): Motor shall be brushless DC type specifically designed for applications with heavy duty ball bearings and electronic commutation. The motor shall be speed controllable down to 20% of full speed and 85% efficient at all speeds.

2.1.4. Poly-phase Motors: NEMA Design B, Squirrel cage, induction type.

2.1.5. Two Speed Motors: Each two-speed motor shall have two separate windings. Provide a time- delay (20 seconds minimum) relay for switching from high to low speed.

2.1.6. Number of phases shall be as follows:

2.1.6.1. Motors, less than 373 W (1/2 HP): Single phase.
2.1.6.2. Motors, 373 W (1/2 HP) and larger: 3 phase.
2.1.6.3. Exceptions:
2.1.6.3.1. Hermetically sealed motors.
2.1.6.3.2. Where specified otherwise on the equipment schedules
2.1.6.3.3. Motors for equipment assemblies, less than 746 W (one HP), may be single phase provided the manufacturer of the proposed assemblies cannot supply the assemblies with three phase motors.

2.1.7. Motors shall be designed for operating the connected loads continuously in a 40°C (104°F) environment, where the motors are installed, without exceeding the NEMA standard temperature rises for the motor insulation. If the motors exceed 40°C (104°F), the motors shall be rated for the actual ambient temperatures.

2.1.8. Motor designs, as indicated by the NEMA code letters, shall be coordinated with the connected loads to assure adequate starting and running torque.

2.2. **MOTOR ENCLOSURES**

2.2.1. Shall be the NEMA types as specified and/or shown on the drawings.

2.2.2. Where the types of motor enclosures are not shown on the drawings, they shall be the NEMA types, which are most suitable for the environmental conditions where the motors are being installed.

2.2.3. Enclosure requirements for certain conditions are as follows:

2.2.3.1. Motors located outdoors, indoors in wet or high humidity locations, or in unfiltered airstreams shall be totally enclosed type.
2.2.3.2. Where motors are located in an NEC 511 classified area, provide TEFC explosion proof motor enclosures.
2.2.3.3. Where motors are located in a corrosive environment, provide TEFC enclosures with corrosion resistant finish.
2.2.3.4. Enclosures shall be primed and finish coated at the factory with manufacturer's prime coat and standard finish.

2.2.4. Special Requirements:

2.2.4.1. Where motor power requirements of equipment furnished deviate from power shown on plans, provide electrical service designed under the requirements of NFPA 70 without additional time or cost to the Client.

2.2.4.2. Assemblies of motors, starters, controls and interlocks on factory assembled and wired devices shall be in accordance with the requirements of this specification.

2.2.5. Wire and cable materials specified in the electrical division of the specifications shall be modified as follows:

2.2.5.1. Wiring material located where temperatures can exceed 71 degrees C (160 degrees F) shall be stranded copper with Teflon FEP insulation with jacket. This includes wiring on the boilers.

2.2.5.2. Other wiring at boilers and to control panels shall be NFPA 70 designation THWN.

2.2.5.3. Provide shielded conductors or wiring in separate conduits for all instrumentation and control systems where recommended by manufacturer of equipment.

2.2.6. Select motor sizes so that the motors do not operate into the service factor at maximum required loads on the driven equipment. Motors on pumps shall be sized for non-overloading at all points on the pump performance curves.

2.2.7. Motors less than 3 HP:

2.2.7.1. Steel or cast iron motor frames, cast aluminum, cast iron, or steel end plates, steel or cast iron terminal box, copper windings. Motor nameplates shall be steel, engraved-type, riveted to motor.

2.2.7.2. Bearings: Regreasable with relief plugs, pre-lubricated ball bearings suitable for radial and thrust loading of the application, with grease fittings, selected for a minimum L-10bearing life of 26,280 hours, for belted and direct drive.

2.2.8. Motors 3 HP and above:

2.2.8.1. Cast iron motor frame and mounting feet, cast iron end plates (bells), steel or cast iron terminal box, copper windings. Motor nameplates shall be stainless steel engraved type, riveted to the motor.

2.2.8.2. Bearings shall be regreasable with relief plugs, pre-lubricated ball bearings suitable for radial and thrust loading of the application, with grease fittings. Rated for an L-10 life of 40,000 hours (belted) or 130,000 hours (direct connected).

2.2.9. Bearing life calculations shall be per ABMA 9, and for belted applications shall be based on the maximum external side load limits for belted applications per NEMA MG-1 Table 14-1A. L-10 life calculations for vertical motors and horizontal motors mounted in the vertical position shall consider the application's thrust loading.

2.2.10. TEFC motors shall also include an external shaft slinger on drive end.

2.2.11. Motors shall not exceed dBA levels listed in NEMA MG-1 54 PART 9 Tables 9-1 and 9-3, at all speeds.

2.2.12. Motors utilized with variable frequency drives shall be rated “inverter-duty” per NEMA Standard, MG1, Part 31.4.4.2. Provide motor shaft grounding apparatus that will protect bearings from damage from stray currents.

2.3. **ENERGY EFFICIENT MOTORS (MOTOR EFFICIENCIES):**

2.3.1. All permanently wired polyphase motors of 746 Watts (1 HP) or more shall meet the minimum full-load efficiencies as indicated in the following table.

2.3.2. Motors of 746 Watts or more with open, drip-proof or totally enclosed fan-cooled enclosures shall be NEMA premium efficiency type, unless otherwise indicated.

2.3.3. Motors provided as an integral part of motor driven equipment are excluded from this requirement if a minimum seasonal or overall efficiency requirement is indicated for that equipment by the provisions of another section.

Minimum Premium Efficiencies Open Drip-Proof				**Minimum Premium Efficiencies Totally Enclosed Fan-Cooled**			
Rating kW (HP)	**1200 RPM**	**1800 RPM**	**3600 RPM**	**Rating kW (HP)**	**1200 RPM**	**1800 RPM**	**3600 RPM**
0.746 (1)	82.5%	85.5%	77.0%	0.746 (1)	82.5%	85.5%	77.0%
1.12 (1.5)	86.5%	86.5%	84.0%	1.12 (1.5)	87.5%	86.5%	84.0%
1.49 (2)	87.5%	86.5%	85.5%	1.49 (2)	88.5%	86.5%	85.5%
2.24 (3)	88.5%	89.5%	85.5%	2.24 (3)	89.5%	89.5%	86.5%
3.73 (5)	89.5%	89.5%	86.5%	3.73 (5)	89.5%	89.5%	88.5%
5.60 (7.5)	90.2%	91.0%	88.5%	5.60 (7.5)	91.0%	91.7%	89.5%
7.46 (10)	91.7%	91.7%	89.5%	7.46 (10)	91.0%	91.7%	90.2%
11.2 (15)	91.7%	93.0%	90.2%	11.2 (15)	91.7%	92.4%	91.0%
14.9 (20)	92.4%	93.0%	91.0%	14.9 (20)	91.7%	93.0%	91.0%
18.7 (25)	93.0%	93.6%	91.7%	18.7 (25)	93.0%	93.6%	91.7%

22.4 (30)	93.6%	94.1%	91.7%	22.4 (30)	93.0%	93.6%	91.7%
29.8 (40)	94.1%	94.1%	92.4%	29.8 (40)	94.1%	94.1%	92.4%
37.3 (50)	94.1%	94.5%	93.0%	37.3 (50)	94.1%	94.5%	93.0%
44.8 (60)	94.5%	95.0%	93.6%	44.8 (60)	94.5%	95.0%	93.6%
56.9 (75)	94.5%	95.0%	93.6%	56.9 (75)	94.5%	95.4%	93.6%
74.6 (100)	95.0%	95.4%	93.6%	74.6 (100)	95.0%	95.4%	94.1%
93.3 (125)	95.0%	95.4%	94.1%	93.3 (125)	95.0%	95.4%	95.0%
112 (150)	95.4%	95.8%	94.1%	112 (150)	95.8%	95.8%	95.0%

2.3.4. Minimum Power Factor at Full Load and Rated Voltage: 90 percent at 1200 RPM, 1800 RPM and 3600 RPM.

PART 3 - EXECUTION

3.1. **INSTALLATION**

Install motors in accordance with manufacturer's recommendations, the NEC, NEMA, as shown on the drawings and/or as required by other sections of these specifications.

3.2. **FIELD TESTS**

3.2.1. Perform an electric insulation resistance Test using a megohmmeter on all motors after installation, before start-up. All shall test free from grounds.

3.2.2. Perform Load test in accordance with ANSI/IEEE 112, Test Method B, to determine freedom from electrical or mechanical defects and compliance with performance data.

3.2.3. Insulation Resistance: Not less than one half meg-ohm between stator conductors and frame, to be determined at the time of final inspection.

3.2.4. All test data shall be complied into a report form for each motor and provided to the contracting officer or their representative.

3.3. **STARTUP AND TESTING**

3.3.1. The Commissioning Agent will observe startup and contractor testing of all equipment. Coordinate the startup and contractor testing schedules with Resident Engineer and Commissioning Agent. Provide a minimum of 7 days prior notice.

TABLE OF CONTENTS

PART 1 - GENERAL

1.1. **DESCRIPTION**

1.1.1. This section specifies the application of noise and vibration control techniques to boiler plant rotating equipment including pumps, fans, compressors and motors.

1.2. **RELATED WORK**

1.2.1. Section: 01 33 23 Shop Drawings, Product Data, and Samples.

1.3. **SUBMITTALS**

1.3.1. Submit in accordance with Section: 01 33 23 Shop Drawings, Product Data, and Samples.

1.3.1.1. Noise and Vibration Control Devices; include with the equipment submittals.

1.3.1.2. Provide separate shop drawings for each isolated system complete with performance and product data.

1.3.1.3. Submit type of isolator, size, height when uncompressed and maximum allowable static deflection weight of all isolated equipment, loads on each isolator and static deflection of each isolator under the specific design load.

1.3.1.4. Submit marked up plans indicating all locations where pipes are to be isolated in mechanical rooms and as specified.

1.4. **APPLICABLE PUBLICATIONS**

1.4.1. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by basic designation only.

1.4.2. ASHRAE - 1995 - HVAC Applications, Chapter 43 - “Sound and Vibration Control”.

1.5. **SCOPE OF WORK**

1.5.1. Provide vibration control items for isolating vibration of mechanical equipment, piping and ductwork.

1.5.2. Provide all hangers, isolators, bases, pads, sleeves and other devices specified, required, or detailed for the project. Include all vibration isolation system elements as recommended by the equipment manufacturer’s representative to make a complete, correct and safe installation. Supply and install all incidental materials needed.

1.6. **QUALITY ASSURANCE**

1.6.1. Work of this section shall be performed by skilled workers who are experienced in the necessary crafts to meet the requirements of this Section.

1.6.2. Provide field supervision and inspection to assure proper installation, adjustment and performance. Replace any isolators that are found to resonate with the supported equipment.

1.6.3. As a minimum provide vibration control per ASHRAE - 1995 - HVAC Applications, Chapter 43 - "Sound and Vibration Control".

1.6.4. Isolators shall be selected, installed and adjusted to prevent the transmission of objectionable vibration and noise to the building structure.

1.6.5. The size and number of mounts and hangers shall be chosen to meet these specifications, even if not specifically shown on the plans. Brackets, rails, bases, braces, etc., shall be provided as needed for a complete and correct installation.

1.7. **ACCEPTABLE MANUFACTURERS**

1.7.1. Subject to compliance with the Contract Documents, manufacturers for products specified in this Section shall be one of the following:

1.7.1.1. Kinetics Noise Controls.
1.7.1.2. Mason Industries, Inc.
1.7.1.3. Vibron Ltd.

PART 2 - PRODUCTS

2.1. **SUSPENDED VIBRATION ISOLATION**

2.1.1. Combination isolation hanger assembly with neoprene insert

2.1.1.1. Vibration isolators for suspended equipment with minimum static deflection requirement exceeding 0.4" (10 mm), and where both high and low frequency vibrations are to be isolated, shall be hangers consisting of a laterally stable spring in series with an elastomer-in-shear insert complete with load transfer plates and assembled in a stamped or welded steel bracket.

2.1.1.2. The bracket shall be finished with an polyester powder coating. The manufacturer shall provide independent laboratory testing showing that the bracket with this finish has endured a minimum of 1,000 hours of exposure to salt spray fog testing per ASTM B117 without signs of corrosion.

2.1.1.3. The elastomer insert shall be molded from oil-resistant compounds and shall be color coded to indicate load capacity and selected to operate within its published load range.

2.1.1.4. The spring element shall have a minimum lateral stiffness of 1.0 times the rated vertical stiffness.

2.1.1.5. Springs shall be color coded or otherwise identified to indicate load capacity.

2.1.1.6. The hanger bracket shall be designed to carry a 500% overload without failure and to allow a support rod misalignment through a 30° arc without metal-to-metal contact or other short circuit.

2.1.1.7. The 1" and 2" hanger brackets shall incorporate spring caps with indexed steps which correspond to the washer diameter of appropriately sized hanger rod to keep the rod centered in the spring cap and reduce rod misalignment. The spring caps are protected under U.S. patent number 5,653,426.

2.1.1.8. Isolation hangers shall be selected by the manufacturer for each specific application to comply with deflection requirements as shown on the Vibration Isolation Schedule or as indicated on the project documents.

2.1.1.9. *Applications: Suspended mechanical equipment such as in-line fans, cabinet fans, and piping and ductwork in close proximity to mechanical equipment.*

2.1.1.10. Standard of Acceptance: Kinetics Noise Control SRH series.

2.1.2. Neoprene Isolation Hangers

2.1.2.1. Vibration isolators with maximum static deflection requirements under operating load conditions not exceeding 0.57" (15 mm) shall be hangers consisting of an elastomer-in-shear insert encased in a welded steel bracket and provided with a stamped load transfer cap.

2.1.2.2. The elastomer insert shall be molded from oil resistant compounds, shall be color coded to indicate load capacity and selected to operate within its published load range.

2.1.2.3. The hanger bracket shall be designed to carry a 500% overload without failure and to allow support rod misalignment through a 30° arc without metal-to-metal contact or other short circuit.

2.1.2.4. Isolation hangers shall be selected by the manufacturer for each specific application to comply with deflection requirements as shown on the Vibration Isolation Schedule or as indicated on the project documents.

2.1.2.5. *Applications: isolation of vibration produced by suspended mechanical equipment, in-line and exhaust fans, ductwork, piping.*

2.1.2.6. Standard of Acceptance: Kinetics Noise Control SRH series.

2.1.3. Piping Hangers Spring Vibration isolators

2.1.3.1. Vibration isolators for suspended equipment with minimum static deflection requirement exceeding 0.4" (10 mm), and where both high and low frequency vibrations are to be isolated, shall be hangers consisting of a laterally stable spring in series with an elastomer-in-shear insert complete with load transfer plates and assembled in a stamped or welded steel bracket.

2.1.3.2. The bracket shall be finished with a polyester powder coating. The manufacturer shall provide independent laboratory testing showing that the bracket with this

finish has endured a minimum of 1,000 hours of exposure to salt spray fog testing per ASTM B117 without signs of corrosion.

2.1.3.3. The elastomer insert shall be molded from oil-resistant compounds and shall be color coded to indicate load capacity and selected to operate within its published load range.

2.1.3.4. The spring element shall have a minimum lateral stiffness of 1.0 times the rated vertical stiffness.

2.1.3.5. Springs shall be color coded or otherwise identified to indicate load capacity.

2.1.3.6. The hanger bracket shall be designed to carry a 500% overload without failure and to allow a support rod misalignment through a 30° arc without metal-to-metal contact or other short circuit.

2.1.3.7. The 1" and 2" hanger brackets shall incorporate spring caps with indexed steps which correspond to the washer diameter of appropriately sized hanger rod to keep the rod centered in the spring cap and reduce rod misalignment. The spring caps are protected under U.S. patent number 5,653,426.

2.1.3.8. Isolation hangers shall be selected by the manufacturer for each specific application to comply with deflection requirements as shown on the Vibration Isolation Schedule or as indicated on the project documents.

2.1.3.9. *Application: first three pipe hangers upstream/downstream of pumping equipment.*

2.1.3.10. The combination isolation hanger assembly with neoprene insert shall be Model SRH, as manufactured by Kinetics Noise Control, Inc.

2.2. **FLOOR MOUNTED VIBRATION ISOLATION**

2.2.1. Restrained Spring Isolators

2.2.1.1. Vibration isolators for equipment which is subject to load variations and large external or torquing forces shall consist of large diameter laterally stabile steel springs assembled into welded steel housing assemblies designed to limit vertical movement of the supported equipment.

2.2.1.2. Housing assemblies shall be fabricated steel members and shall consist of a top load plate complete with adjusting and leveling bolts, vertical restraints, isolation washers and a bottom plate with internal non-skid noise isolation pads. Housing shall be electrozinc plated or hot dip galvanized for corrosion resistance. Housing should be designed to provide a constant free and operating height within 1/8" (0.06 mm).

2.2.1.3. Spring elements shall have a lateral stiffness greater than 1.2 times the rated vertical stiffness and shall be designed to provide a minimum of 50% overload capacity. Non-welded spring elements shall be polyester powder coated, and shall have a 1000 hr rating when tested in accordance with ASTM B-117.

2.2.1.4. All springs shall have a minimum additional travel to solid equal to 50% of the rated deflection. All springs except internal nested springs shall have an outside diameter not less than 0.8 of the compressed height of the spring. Ends of springs shall be square and ground for stability. Laterally stable springs shall have kx/ky ratios of at least 0.9. All springs shall be fully color-coded to indicate capacity – color striping is not considered adequate.

2.2.1.5. Corrosion Protection: All springs shall be powder-coated enamel. Housings shall be galvanized, powder-coated enamel, or painted with rust-resistant paint. Hot-dipped galvanized housings shall be provided as indicated on the Schedule

2.2.1.6. Operating static deflections are available up to 4" (102 mm) to compensate for long span flexible floor structures and maintain a high degree of noise and vibration isolation.

2.2.1.7. Springs shall be selected to provide maximum deflections; select from manufacturer's literature based on supported equipment weight. Springs shall be color coded or otherwise identified to indicate load capacity.

2.2.1.8. *Vertically restrained spring isolation mounts are recommended as a noise and vibration isolator for heavy mechanical equipment, or when the equipment to be isolated has significant changes of weight during maintenance operations, and for equipment subjected to moderate external forces or wind loads, such as such as chillers, cooling towers, condensing units larger than 50 ton capacity, air handlers and utility type exhaust fans larger than 10,000 cfm capacity, and similar.*

2.2.1.9. Standards of Acceptance: Kinetics Nose Controls FRS (supported weight up to 1,500 kg) or FLS series (supported equipment weight above 1,500 kg).

2.2.2. Neoprene Isolation Pads

2.2.2.1. Isolation pads shall be single ribbed or crossed, double ribbed elastomer-in-shear pads, in combination with steel shims when required, having maximum deflections between 0.08" to 0.14"

2.2.2.2. All pads shall be true elastomer-in-shear using alternately higher and lower ribs to provide effective vibration isolation, and shall be molded using 2500 PSI (176 kg/cm2) tensile strength, oil resistant compounds with no color additives.

2.2.2.3. Pads shall be 45 to 65 durometer and designed to permit 60 or 120 PSI (4.2 or 8.4 kg/cm2) loading at maximum rated deflections.

2.2.2.4. When two isolation pads are laminated, they shall be separated by, and bonded to, a galvanized steel shim plate.

2.2.2.5. *Application: floor/concrete curb/sleeper mounted equipment such as boilers pumps, utility type exhaust fans of less than 10,000 cfm capacity, condensing units of less than 50 ton capacity, condensers/fluid coolers, and similar*

2.2.2.6. Standard of Acceptance: Kinetics Noise Control models NPS, NPD, NGS or NGD to suit weight of equipment and max. deflection rates.

2.2.3. Elastomeric Isolation Mounts

2.2.3.1. One-piece molded neoprene mounts with encapsulated metal inserts, color coded to identify capacity, with non-skid ribs on the bottom load surfaces. Each isolator incorporates two bolt-down holes on the bottom load surface and a tapped steel load top plate for attachment to the supported equipment. The neoprene is highly oil resistant and has been designed to operate within the strain limits of the isolator to provide maximum isolation and longest life expectancy possible using neoprene compounds.

2.2.3.2. *Isolation mounts are designed for up to 0.5" (13 mm) deflection, available in four sizes and eleven capacities from 55 lbs. to 4,000 lbs. (25 kg to 1814 kg).*

2.2.3.3. Standard of Acceptance: Kinetics Noise Control model RDS.

2.2.4. Inertia Base Pads

2.2.4.1. Isolation bases shall be constructed of concrete cast into fabricated inertia base frames, the steel members of which are designed and supplied by the isolator manufacturer. The concrete shall be poured into a welded steel frame, incorporating prelocated equipment anchor bolts, 1/2-in (13 mm) diameter reinforcing bars on nominal 8-in (203 mm) centers each way, and recessed isolator mounting brackets to reduce the mounting height of the equipment, and reduce the footprint of the base. The thickness of the base shall be a minimum of 8% of the longest span between isolators, at least 6 in (152 mm), or as indicated on the drawings. Where inertia bases are used to mount pumps, the bases shall be sized to support piping elbows.

2.2.4.2. Applications: Support of heavy equipment where preventing noise transmission to adjacent spaces is critical. Inertia bases are used to support mechanical equipment, reduce equipment vibration, provide for attachment of vibration isolators, prevent differential movement between driving and driven members, reduce rocking by lowering equipment center of gravity, reduce motion of equipment during start-up and shut-down, act to reduce reaction movement due to operating loads on equipment, and act as a noise barrier.

2.2.4.3. *Typical uses for inertia base frames, with poured concrete and supported by noise and vibration isolators, include use with open-type centrifugal chillers, reciprocating air and refrigeration compressors, chillers, and heat pumps, close-coupled and base-mounted pumps, centrifugal fans, internal combustion engines, and similar types of equipment.*

2.2.4.4. Standard of Acceptance: Kinetics Noise Control model CIB-L

2.2.5. Vibration isolator Rails

2.2.5.1. Spring components shall be 1"/25 mm for air handling equipment/condensing units and 2"/50 mm deflection for cooling towers/chillers, free-standing, un-

housed, laterally stable steel springs. Springs shall have a lateral stiffness greater than 1.0 times the rated vertical stiffness and shall be designed for 50% overload to solid.

2.2.5.2. Springs shall be color coded to indicate load capacity.

2.2.5.3. Rails shall provide continuous support for the rooftop equipment and shall be designed to provide isolation against casing-radiated vibration in the rooftop equipment housing and structure borne vibration from rotating and mechanical equipment in the rooftop package.

2.2.5.4. Rail assembly shall consist of extruded aluminum top and bottom members connected by spring isolators and a continuous air- and water-tight seal. The seal shall be a beaded elastomeric material retained in a keyway along the top extrusion. The weather strip shall be sealed along the bottom with an aluminum fascia strip.

2.2.5.5. Rail assemblies shall incorporate means for attachment to the building and the supported equipment and shall incorporate additional stiffening members if necessary to assure stability.

2.2.5.6. Vibration isolators shall be selected by the manufacturer for each specific application to comply with deflection requirements as shown on the Vibration Isolation Schedule or as indicated on the project documents.

2.2.5.7. *Application: designed and engineered to isolate packaged roof mounted equipment from the roof structure. Typical applications: cooling tower, condensing units, roof mounted air handling equipment and similar*

2.2.5.8. Where specified, the vibration isolation rails shall have a positive elastomeric air and weather seal permitting the inside of the unit to be used as a return air plenum. The KSR mates with the inside of the manufacturers' curb eliminating any internal interference.

2.2.5.9. Standard of Acceptance: Kinetics Noise Control Model KSR

2.3. **PIPING CONNECTIONS**

2.3.1. Flexible Piping Connectors

2.3.1.1. Flexible Braided Hose Connectors – HVAC Systems

2.3.1.1.1. Type 321 Stainless Steel Hose with type 304 Stainless Steel Outer Braid and 150# Carbon Steel Flat Faced Drilled Bolting Flanges

2.3.1.1.2. Length: 229 mm (9") to 356" (14") depending on diameter. max. lateral offset: 10 mm (0.125")

2.3.1.1.3. Application: piping connected to rotating equipment to reduce the transmission of noise and vibration, and to eliminate stresses in piping systems due to misalignment and thermal movement of the piping, where fluid temperature may exceed 90^{O}C.

2.3.1.1.4. Standard of Acceptance: Kinetics Noise Control model BFMC-FFF

2.3.1.2. Refrigerant Piping Flexible Hose Connectors

2.3.1.2.1. Bronze flexible bellows with bronze braided outer cover and shall have bronze female copper sweat ends.

2.3.1.2.2. Standards of Acceptance: Kinetics Nose Control model BFMC-CFE

2.3.2. Twin Sphere Neoprene Connector

2.3.2.1. Made of molded EPDM reinforced with nylon tire cord and shall have mild steel floating flanges. Use control rods to limit deflections and movements to within the prescribed values indicated by the manufacturer.

2.3.2.2. Axial compression: 50 mm (2"). Axial elongation: 30 mm (1.25"). Transverse movement: 40 mm (1.5")

2.3.2.3. Application: piping connected to rotating equipment piping connected to rotating equipment to reduce the transmission of noise and vibration, and to eliminate stresses in piping systems due to misalignment and thermal movement of the piping, where fluid temperatures remain in the -10 deg. C to 90 deg. C (14 deg. F to 190 deg. F).

2.3.2.4. Standard of Acceptance: Kinetics Noise Control model FTC

2.4. **DUCTWORK CONNECTIONS**

2.4.1. Ductwork Flexible Connector

2.4.1.1. Fully welded match drilled carbon steel flanges equipped with backing bars fastened in place with zinc plated hardware and EPDM flex membrane material. Acoustically rated design shall be used where called for on the design documentation, with an absorptive acoustic fill and EPDM outer barrier.

2.4.1.2. EPDM Flexible material: 1/8" thick layered EPDM flex membrane with internal nylon scrim for superior tear strength. Resistant to ozone and UV exposure and cold cracking (suitable for outdoor use).

2.4.1.3. Aerodynamic protective metal flow liner for air streams in excess of 6,000 cfm.

2.4.1.4. Construction: flange to flange distance: 200 mm (8") static mode. Lateral and axial movement: +/- 12.5 mm (1/2 inch). Operating temperature: up to 100 deg. C (212 deg. F)

2.4.1.5. Application: between fans (intake and discharge) and ductwork.

2.4.1.6. *Exception: not required for air handling units where fans are internally isolated*

2.4.1.7. Standard of Acceptance: Kinetics Noise Control model Kineflex

PART 3 - EXECUTION

3.1. **GENERAL**

3.1.1. Statically and dynamically balance all pumps, fans, compressors and drivers. Align shafts of pumps, fans, and drivers to limit noise and vibration to specified values. Level and anchor equipment as necessary to achieve and maintain alignment.

3.1.2. All equipment mounted on vibration isolators springs shall have a minimum operating clearance of 2 inches between the bottom of the equipment or inertia base (and height saving bracket) and the concrete housekeeping pad (or bolt heads) beneath the equipment.

3.1.3. Check the clearance to ensure that no scraps have been left to short circuit the vibration isolators.

3.1.4. Provide a minimum of 4 inches between isolated equipment and the walls, ceiling, floors, columns and any other equipment not installed on vibration isolators.

3.1.5. Piping, ductwork, conduit or mechanical equipment shall not be hung from or supported on other equipment, pipes, or ductwork installed on vibration isolators.

3.1.6. Equipment connected to water or other fluid piping shall be erected on isolators or isolated foundations at correct operating heights prior to connection of piping. Equipment should be blocked-up with temporary shims to final operating height. When the system is assembled and fluid is added, the isolators shall be adjusted to allow removal of the shims.

3.1.7. All mechanical equipment not specifically identified in this specification that contains rotating or vibration elements shall be installed on neoprene isolators as appropriate. Provide supporting steel structure between isolators and equipment if isolator does not readily connect to equipment.

3.2. **FLOOR MOUNTED PUMPS**

3.2.1. Neoprene Isolation pads with or without inertia concrete pads – as specified or shown on the drawings.

3.3. **FLOOR MOUNTED BOILERS**

3.3.1. Neoprene isolation pads – select to suit equipment weight.

3.4. **FLOOR MOUNTED FANS AND AIR HANDLING EQUIPMENT**

3.4.1. Neoprene isolation pads (less than 10,000 cfm), restrained springs (above 10,000 cfm) with or without inertia concrete pads, as specified or shown on the drawings. Secure springs to equipment and pads.

3.5. **FLOOR OR ROOF MOUNTED CHILLERS/COOLING TOWERS**

3.5.1. Restrained springs or vibration isolation rails, number and location of springs coordinated with the equipment manufacturer and selected to suit equipment weight. For indoor equipment, use inertia isolation pads where shown on the drawings. Secure springs or rails to equipment and support structure (outdoors) or pads (indoors).

3.6. **PIPING ISOLATION**

3.6.1. Use flexible hoses or neoprene vibration isolators at all connections between piping and equipment containing rotating parts (pumps, air handlers, chillers, cooling towers, etc). Applicable to refrigerant piping as well. Do not use neoprene isolators outdoors or where fluid temperatures temperature not suitable.

3.6.2. Use restrained spring isolators for the first three piping supports upstream and downstream of each pump.

3.7. **CEILING SUSPENDED EQUIPMENT**

3.7.1. Restrained spring isolators or neoprene isolation pads, as indicated on the drawings

3.8. **AIR COOLED CONDENSING UNITS**

3.8.1. Neoprene pad or elastomeric mounts secured to the support structure and equipment base rails (less than 50 ton capacity). Select based on equipment weight.

3.8.2. Restrained springs or vibration isolator rails secured to the support structure and equipment base rails (over 50 ton capacity). Select based on equipment weight.

3.9. **AIR COOLED CONDENSING UNITS**

3.9.1. Neoprene pad or elastomeric mounts secured to the support structure and equipment base rails

3.10. **ROOFTOP AIR HANDLING UNITS AND UTILITY TYPE EXHAUST FANS**

3.10.1. Vibration isolation rails (where specified)

3.11. **DUCT CONNECTORS**

3.11.1. At all connections between fans and ductwork, where not provided by the manufacturer.

3.11.2. Exception: kitchen grease exhaust ductwork connection to exhaust fan.

3.12. **ELECTRICAL CONNECTIONS**

3.12.1. All wiring connections to mechanical equipment on vibration isolators (either spring or neoprene type) shall be made with a minimum 36 inch long flexible liquid-tight conduit in a 360° loop. Coordinate wiring connections with the electrical sub-trade.

3.13. **INSPECTION**

3.13.1. Supplier shall inspect and approve the installation of the vibration isolators and shall submit a report to the Client which verifies that all of the isolation equipment has been properly installed and that the installation is in full conformance with the specification. The report shall record the vibration isolator identification and model or type.

3.13.2. For isolators containing steel springs the report shall also record the size and uncompressed height, design static deflection and measured static deflection of the isolators provided.

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PART 1 - GENERAL

1.1. **RELATED DOCUMENTS**

1.1.1. Drawings and general provisions of the Contract apply to this Section.

1.1.1.1. Section: 23 31 13 Metal Ducts.

1.2. **SUMMARY**

1.2.1. Section Includes:

1.2.1.1. Equipment labels.
1.2.1.2. Warning signs and labels.
1.2.1.3. Pipe labels.
1.2.1.4. Valve tags.
1.2.1.5. Duct labels.

1.2.2. For BAS identification, also refer to requirements of Section: 23 09 00 Instrumentation and Control for HVAC.

1.3. **SUBMITTAL**

1.3.1. Product Data: For each type of product indicated.

PART 2 - PRODUCTS

2.1. **STANDARDS OF ACCEPTANCE**

2.1.1.1. Brady, Kolbi, or Panduit.

2.2. **EQUIPMENT LABELS**

2.2.1.1. Metal Labels for Equipment:
2.2.1.1.1. Material and Thickness: Brass, 0.032-inch minimum thickness, and having pre-drilled or stamped holes for attachment hardware.
2.2.1.1.2. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
2.2.1.1.3. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.

2.2.2. Fasteners: Stainless-steel rivets or self-tapping screws.

2.2.3. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

2.2.4. Plastic Labels for Equipment:

2.2.4.1. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch thick, and having predrilled holes for attachment hardware.

2.2.4.2. Letter Color: White.

2.2.4.3. Background Color: Black.

2.2.4.4. Maximum Temperature: Able to withstand temperatures up to 160 deg F.

2.2.4.5. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.

2.2.4.6. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.

2.2.5. Fasteners: Stainless-steel rivets or self-tapping screws.

2.2.6. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

2.2.7. Label Content: Include equipment's Drawing designation or unique equipment number, Drawing numbers where equipment is indicated (plans, details, and schedules), plus the Specification Section number and title where equipment is specified.

2.2.8. Label is to also indicate area and type of service being provided.

2.2.8.1. For Example AHU - 3 - floors 1-4

2.2.8.2. P3 HW Hot Water Pump - building perimeter

2.2.9. Equipment Label Schedule: For each item of equipment to be labeled, on 8-1/2-by-11-inch bond paper. Tabulate equipment identification number and identify Drawing numbers where equipment is indicated (plans, details, and schedules), plus the Specification Section number and title where equipment is specified. Equipment schedule shall be included in operation and maintenance data.

2.3. **WARNING SIGNS AND LABELS**

2.3.1. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch thick, and having predrilled holes for attachment hardware.

2.3.2. Letter Color: White.

2.3.3. Background Color: Red.

2.3.4. Maximum Temperature: Able to withstand temperatures up to 160 deg F.

2.3.5. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.

2.3.6. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.

2.3.7. Fasteners: Stainless-steel rivets or self-tapping screws.

2.3.8. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

2.3.9. Label Content: Include caution and warning information, plus emergency notification instructions.

2.4. **PIPE LABELS**

2.4.1. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, showing flow direction, and area served (i.e. perimeter heating hot water).

2.4.2. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.

2.4.3. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings, pipe size, and an arrow indicating flow direction.

2.4.4. Flow-Direction Arrows: Integral with piping system service lettering to accommodate both directions, or as separate unit on each pipe label to indicate flow direction, and visible all around pipe.

2.4.5. Lettering Size: At least 1-1/2 inches high.

2.4.6. All piping, except that piping which is within inaccessible chases, shall be identified.

2.4.7. Each marker background shall be appropriately color coded with a clearly printed legend to identify the contents of the pipe in conformance with the “Scheme for the Identification of Piping Systems” (ASME A13.1-1981).

2.4.8. Set mark snap-around markers shall be used for overall diameters up to 6” and strap around markers shall be used above 6” overall diameters.

2.4.9. Markers shall be located:

2.4.9.1. Adjacent to each valve
2.4.9.2. At each branch
2.4.9.3. At each cap for future
2.4.9.4. At each riser takeoff,
2.4.9.5. At each pipe passage through wall (each side)

2.4.9.6. At each pipe passage at 20’ – 0” intervals maximum.
2.4.9.7. At each piece of equipment.
2.4.9.8. At all access doors.
2.4.9.9. A minimum of one (1) marker shall be provided at each room.

2.5. **VALVE TAGS**

2.5.1. Valve tags shall be according to project valve specification section(s). Unless required differently in project valve specification section(s), valve tags to be minimum 1.5" round brass, attached with metallic chains.

2.6. **DUCT LABELS**

2.6.1. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch thick, and having predrilled holes for attachment hardware.

2.6.1.1. Letter Color: White.
2.6.1.2. Background Color: Red.
2.6.1.3. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
2.6.1.4. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
2.6.1.5. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.

2.6.2. Fasteners: Stainless-steel rivets or self-tapping screws.

2.6.3. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

2.6.4. Duct Label Contents: Include identification of duct service using same designations or abbreviations as used on Drawings, duct size, and an arrow indicating flow direction.

2.6.5. Flow-Direction Arrows: Integral with duct system service lettering to accommodate both directions, or as separate unit on each duct label to indicate flow direction.

2.6.6. Lettering Size: At least 1-1/2 inches high.

2.6.7. Markers shall be located:

2.6.7.1. Adjacent to each air handling equipment
2.6.7.2. At each branch
2.6.7.3. At each cap for future
2.6.7.4. At each riser takeoff,
2.6.7.5. At each duct passage through wall (each side)

2.6.7.6. On each duct straight run at 20' – 0" intervals maximum.

2.6.7.7. At all access doors.

2.6.7.8. A minimum of one (1) marker shall be provided at each room.

2.7. **OTHER SPECIALIZED LABELING AND REQUIREMENTS**

2.7.1. Fire damper access panels shall be permanently identified on the exterior by labels not less than 2" in height reading "FIRE DAMPER".

2.7.2. Smoke damper access panels shall be permanently identified on the exterior by labels not less than 2" in height reading "SMOKE DAMPER".

2.7.3. Combination fire/smoke damper access panels shall be permanently identified on the exterior by labels not less than 2" in height reading "RESETTABLE FIRE/SMOKE DAMPER". Mark the other access panels "FIRE/SMOKE DAMPER."

2.7.4. Items listed in items 1-3 above, will also be listed on a full size, laminated print and left in the main mechanical room as indicated above.

2.7.5. Duct static pressure sensors shall be permanently identified on the exterior by labels not less than 2" in height reading "STATIC PRESSURE SENSOR".

2.7.6. Humidity sensors in ductwork shall be permanently identified on the exterior by labels not less than 2" in height reading "HUMIDITY SENSOR".

2.7.7. Abbreviations: No abbreviations to be used.

2.7.8. All smoke and fire damper locations are to be posted as a pdf on the DDC system per fan system. This information is also to be located in the fire command center for the building. Coordinate with other trades to make sure this happens, and support as required via that coordination.

2.8. **STENCILING**

2.8.1. Not allowed.

PART 3 - EXECUTION

3.1. **PREPARATION**

3.1.1. Clean piping and equipment surfaces of substances that could impair bond of identification devices, including dirt, oil, grease, release agents, and incompatible primers, paints, and encapsulants.

3.2. **EQUIPMENT LABEL INSTALLATION**

3.2.1. Install or permanently fasten labels on each major item of mechanical equipment.

3.2.2. Locate equipment labels where accessible and visible.

3.3. **VALVE TAG INSTALLATION AND DOCUMENTATION**

3.3.1. Tag valves according to project valve specification section(s), and provide typed list (loose and framed under glass) per same specification section(s).

3.3.2. A valve tag schedule is to be mounted in each mechanical room and on every floor (for that respective floor) in a location to be determined by the Consultant

3.3.3. Each valve tag schedule will have an associated architectural print showing each valve location.

3.3.4. At project completion two additional hard copies are to be provided in addition to an electronic copy.

3.3.5. Two copies of the mechanical piping flow diagram will be supplied. All prints that are supplied that are located in mechanical rooms are to be laminated.

3.3.6. Pipe tags that are the first isolation for a utility in a mechanical room or building need to have indicated where the next upstream valve is located and the associated valve number indicated on the valve tag.

3.3.7. This is applicable for all utility isolation valves for each mechanical room space.

3.4. **DUCT LABEL INSTALLATION**

3.4.1. Install self-adhesive duct labels with permanent adhesive on air ducts in the following color codes:

3.4.1.1. Blue: For cold-air supply ducts.
3.4.1.2. Yellow: For hot-air supply ducts.
3.4.1.3. Green: For exhaust-, outside-, relief-, return-, and mixed-air ducts.
3.4.1.4. ASME A13.1 Colors and Designs: For hazardous material exhaust.

3.4.2. Locate labels at maximum intervals of 10 feet, at every change in direction, and within 3' of wall and floor penetrations on both sides of same.

3.4.3. Along with all other ducting on the job, label toxic exhaust.

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PART 1 - GENERAL

1.1. **DESCRIPTION**

1.1.1. Testing, adjusting, and balancing (TAB) of heating, ventilating and air conditioning (HVAC) systems. TAB includes the following:

1.1.1.1. Planning systematic TAB procedures.
1.1.1.2. Design Review Report.
1.1.1.3. Systems Inspection report.
1.1.1.4. Duct Air Leakage test report.
1.1.1.5. Systems Readiness Report.
1.1.1.6. Balancing air and water distribution systems; adjustment of total system to provide design performance; and testing performance of equipment and automatic controls.
1.1.1.7. Recording and reporting results.

1.1.2. Definitions:

1.1.2.1. TAB: Testing, Adjusting and Balancing; the process of checking and adjusting HVAC systems to meet design objectives.
1.1.2.2. AABC: Associated Air Balance Council.
1.1.2.3. NEBB: National Environmental Balancing Bureau.

1.1.3. Hydronic Systems: Includes chilled water, condenser water, heating hot water and glycol water systems as applicable to the project.

1.1.4. Air Systems: Includes all outside air, supply air, return air, exhaust air and relief air systems, as applicable to the project.

1.1.5. Flow rate tolerance: The allowable percentage variation, minus to plus, of actual flow rate from values (design) in the contract documents.

1.2. **RELATED WORK**

1.2.1. Section: 23 05 00 Common Work Results for HVAC.

1.2.2. Section: 23 31 13 Metal Ducts.

1.3. **QUALITY ASSURANCE**

1.3.1. Qualifications:

1.3.1.1. TAB Agency: The TAB agency shall be a subcontractor of the General Contractor and shall report to and be paid by the General Contractor.

1.3.1.2. The TAB agency shall be either a certified member of AABC or certified by the NEBB to perform TAB service for HVAC, water balancing and vibrations and sound testing of equipment. The certification shall be maintained for the entire duration of duties specified herein. If, for any reason, the agency loses subject certification during this period, the General Contractor shall immediately notify the Consultant and submit another TAB firm for approval.

1.3.2. TAB Specialist: The TAB specialist shall be either a member of AABC or an experienced technician of the Agency certified by NEBB. The certification shall be maintained for the entire duration of duties specified herein.

1.3.3. TAB Specialist shall be identified by the General Contractor within 10 days after the notice to proceed. The TAB specialist will be coordinating, scheduling and reporting all TAB work and related activities and will provide necessary information as required by the Consultant. The responsibilities would specifically include:

1.3.3.1. Shall directly supervise all TAB work.
1.3.3.2. Shall sign the TAB reports that bear the seal of the TAB standard. The reports shall be accompanied by report forms and schematic drawings required by the TAB standard, AABC or NEBB.
1.3.3.3. Would follow all TAB work through its satisfactory completion.
1.3.3.4. Shall provide final markings of settings of all HVAC adjustment devices.
1.3.3.5. Permanently mark location of duct test ports.

1.3.4. All TAB technicians performing actual TAB work shall be experienced and must have done satisfactory work on a minimum of 3 projects comparable in size and complexity to this project. Consultant is to ensure that the Tab Technicians are qualified before work is performed. The lead technician shall be certified by AABC or NEBB

1.3.5. Test Equipment Criteria: The instrumentation shall meet the accuracy/calibration requirements established by AABC National Standards or by NEBB Procedural Standards for Testing, Adjusting and Balancing of Environmental Systems and instrument manufacturer. Provide calibration history of the instruments to be used for test and balance purpose.

1.3.6. Tab Criteria:

1.3.6.1. Flow rate tolerance: Following tolerances are allowed. For tolerances not mentioned herein follow ASHRAE Handbook "HVAC Applications", Chapter 36, as a guideline. Air Filter resistance during tests, artificially imposed if necessary, shall be at least 100 percent of manufacturer recommended change over pressure drop values for pre-filters and after-filters.
1.3.6.2. Tolerances:

1.3.6.2.1. Air handling unit and all other fans, cubic meters/min (cubic feet per minute): +/-5% of design values noted in the equipment schedules.

1.3.6.2.2. Air terminal units (maximum values): +/-5% of the design values noted on the equipment schedules.

1.3.6.2.3. Exhaust hoods/cabinets: 0% to +10% of the design values noted on the equipment schedules

1.3.6.2.4. Minimum outside air: 0% to +10% of the design values noted on the equipment schedules

1.3.6.2.5. Individual room air outlets and inlets, and air flow rates not mentioned above: +/-5% of the design values noted on the equipment schedules.

1.3.6.2.6. Heating hot water pumps and hot water coils: +/-5% of the design values noted on the equipment schedules.

1.3.6.2.7. Chilled water and condenser water pumps: 0% to +5% of the design values noted on the equipment schedules

1.3.6.2.8. Chilled water coils: 0% to +5% of the design values noted on the equipment schedules.

1.3.6.2.9. Heat output capacities: 0% to +10% of the design values noted on the equipment schedules

1.3.6.2.10. Cooling output capacities: +/-5% of the design values noted on the equipment schedules

1.3.7. Typical TAB procedures and results shall be demonstrated to the Consultant for one air distribution system (including all fans, three terminal units, three rooms randomly selected by the Consultant) and one hydronic system (pumps and three coils) as follows:

1.3.7.1. When field TAB work begins.

1.3.7.2. During each partial final inspection and the final inspection for the project if requested by the Board

1.4. **SUBMITTALS**

1.4.1. Submit in accordance with Section: 01 33 23 Shop Drawings, Product Data, and Samples.

1.4.2. Submit names and qualifications of TAB agency and TAB specialists within 10 days after the notice to proceed. Submit information on three recently completed projects and a list of proposed test equipment.

1.4.3. Submit Following for Review and Approval:

1.4.3.1. Design Review Report within 10 days after the award of contract from the General Contractor.

1.4.3.2. Systems inspection report on equipment and installation for conformance with design.

1.4.3.3. Duct Air Leakage Test Report.

1.4.3.4. Systems Readiness Report.

1.4.4. Intermediate and Final TAB reports covering flow balance and adjustments, performance tests, vibration tests and sound tests.

1.4.5. Include in final reports uncorrected installation deficiencies noted during TAB and applicable explanatory comments on test results that differ from design requirements.

1.4.6. Prior to request for Final or Partial Final inspection, submit completed Test and Balance report for the area.

1.5. **APPLICABLE PUBLICATIONS**

1.5.1. The following publications form a part of this specification to the extent indicated by the reference thereto. In text the publications are referenced to by the acronym of the organization.

1.5.1.1. American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc. (ASHRAE):

1.5.1.2. 2007 HVAC Applications ASHRAE Handbook, Chapter 37, Testing, Adjusting, and Balancing and Chapter 47, Sound and Vibration Control

1.5.1.3. Associated Air Balance Council (AABC):

1.5.1.3.1. AABC National Standards for Total System Balance

1.5.1.3.2. National Environmental Balancing Bureau (NEBB):

1.5.1.3.3. 7th Edition 2005 Procedural Standards for Testing, Adjusting, Balancing of Environmental Systems

1.5.1.3.4. 2nd Edition 2006 Procedural Standards for the Measurement of Sound and Vibration

1.5.1.3.5. 3rd Edition 2009 Procedural Standards for Whole Building Systems Commissioning of New Construction

1.5.1.4. Sheet Metal and Air Conditioning Contractors National Association (SMACNA):

1.5.1.4.1. 3rd Edition 2002 HVAC SYSTEMS Testing, Adjusting and Balancing

PART 2 - PRODUCTS

2.1. **PLUGS**

2.1.1. Provide plastic plugs to seal holes drilled in ductwork for test purposes.

2.2. **INSULATION REPAIR MATERIAL**

2.2.1. See Section: 23 07 00 HVAC Insulation.

2.2.2. Provide for repair of insulation removed or damaged for TAB work.

PART 3 - EXECUTION

3.1. **GENERAL**

3.1.1. Obtain applicable contract documents and copies of approved submittals for HVAC equipment and automatic control systems.

3.1.2. *Coordinate all balancing work with the BAS vendor. Where balancing variable flow systems, fine tune the pressure differential sensor settings to ensure that all end users receive adequate water and air flows.*

3.2. **DESIGN REVIEW REPORT**

3.2.1. The TAB Specialist shall review the Contract Plans and specifications and advise the Consultant of any design deficiencies that would prevent the HVAC systems from effectively operating in accordance with the sequence of operation specified or prevent the effective and accurate TAB of the system. The TAB Specialist shall provide a report individually listing each deficiency and the corresponding proposed corrective action necessary for proper system operation.

3.3. **SYSTEMS INSPECTION REPORT**

3.3.1. Inspect equipment and installation for conformance with design.

3.3.2. The inspection and report are to be done after piping and air distribution equipment is on site and piping/duct installation has begun, but well in advance of performance testing and balancing work. The purpose of the inspection is to identify and report deviations from design and ensure that systems will be ready for TAB at the appropriate time.

3.3.3. Reports: Follow check list format developed by AABC, NEBB or SMACNA, supplemented by narrative comments, with emphasis on air handling units and fans. Check for conformance with submittals. Verify that diffuser and register sizes are correct. Check air terminal unit installation including their duct sizes and routing.

3.4. **DUCT AIR LEAKAGE TEST REPORT**

3.4.1. TAB Agency shall perform the leakage test as outlined in "Duct leakage Tests and Repairs" in Section: 23 31 13 Metal Ducts.

3.5. **SYSTEM READINESS REPORT**

3.5.1. The TAB Contractor shall measure existing air and water flow rates associated with existing systems utilized to serve renovated areas as indicated on drawings. Submit report of findings to Consultant.

3.5.2. Inspect each System to ensure that it is complete including installation and operation of controls. Submit report to Consultant in standard format and forms prepared and or approved by the Commissioning Agent, as applicable to the project.

3.5.3. Verify that all items such as ductwork piping, ports, terminals, connectors, etc., that is required for TAB are installed. Provide a report to the Consultant.

3.6. **TAB REPORTS**

3.6.1. The TAB contractor shall provide raw data immediately in writing to the Consultant if there is a problem in achieving intended results before submitting a formal report.

3.6.2. If over 20 percent of readings in the intermediate report fall outside the acceptable range, the TAB report shall be considered invalid and all contract TAB work shall be repeated and re-submitted for approval at no additional cost to the Board.

3.6.3. Do not proceed with the remaining systems until intermediate reports are reviewed by the Consultant.

3.7. **TAB PROCEDURES**

3.7.1. Tab shall be performed in accordance with the requirement of the Standard under which TAB agency is certified by either AABC or NEBB.

3.7.2. General: During TAB all related system components shall be in full operation. Fan and pump rotation, motor loads and equipment vibration shall be checked and corrected as necessary before proceeding with TAB. Set controls and/or block off parts of distribution systems to simulate design operation of variable volume air or water systems for test and balance work.

3.7.3. For air handling systems, perform balancing work when the building envelope is substantially completed (windows and doors installed, ceilings completed, transfer grilles installed)

3.7.4. For air handling systems equipped with hydronic components, make air and hydronic balancing at the same time.

3.7.5. Air Balance and Equipment Test: Include air handling units, fans, terminal units, fan coil units, room diffusers/outlets/inlets, computer room AC units, and laboratory fume hoods and biological safety cabinets.

3.7.6. Artificially load air filters by partial blanking to produce air pressure drop of manufacturer's recommended pressure drop.

3.7.7. Adjust fan speeds to provide design air flow.

3.7.8. Test and balance systems in all specified modes of operation, including variable volume, economizer, and fire emergency modes. Verify that dampers and other controls function properly.

3.7.9. Variable air volume (VAV) systems:

3.7.9.1. Not applicable to this project

3.7.10. Water Balance and Equipment Test: Include circulating pumps, convertors, heat exchangers, boilers, coils, coolers and condensers

3.7.10.1. Adjust flow rates for equipment.

3.7.10.2. Primary secondary (variable volume) systems: Balance systems at design water flow and then verify that variable flow controls function as designed.

3.7.10.3. Record final measurements for hydronic equipment on performance data sheets. Include entering and leaving water temperatures for heating and cooling coils, and for convertors. Include entering and leaving air temperatures (DB/WB for cooling coils) for air handling units and reheat coils. Make air and water temperature measurements at the same time.

3.8. **LOCATION OF MEASUREMENTS AND MEASURED PARAMETERS**

3.8.1. Perform hydronic measurements at each:

3.8.1.1. Boiler
3.8.1.2. Coil
3.8.1.3. Heat Exchanger
3.8.1.4. Control Valve
3.8.1.5. Balancing Valve

3.8.2. Perform air measurements at each:

3.8.2.1. Fan/Air Handling System discharge
3.8.2.2. Exhaust fan
3.8.2.3. Coil
3.8.2.4. Fresh air/Exhaust damper
3.8.2.5. Terminal unit
3.8.2.6. Air distribution equipment

3.8.3. Measured parameters

3.8.3.1. Air flows
3.8.3.2. Hydronic flows
3.8.3.3. Temperatures entering/leaving coils (hydronic and air)
3.8.3.4. Pressure drops at each measured equipment/device (hydronic and air)

3.8.3.5. Electric Power drawn by electrical equipment

3.9. **MARKING OF SETTINGS**

3.9.1. Following approval of Tab final Report, the setting of all HVAC adjustment devices including valves, splitters and dampers shall be permanently marked by the TAB Specialist so that adjustment can be restored if disturbed at any time. Style and colors used for markings shall be coordinated with the Consultant.

3.10. **IDENTIFICATION OF TEST PORTS**

3.10.1. The TAB Specialist shall permanently and legibly identify the location points of duct test ports. If the ductwork has exterior insulation, the identification shall be made on the exterior side of the insulation. All penetrations through ductwork and ductwork insulation shall be sealed to prevent air leaks and maintain integrity of vapor barrier.

TABLE OF CONTENTS

PART 1 - GENERAL

1.1. **DESCRIPTION**

1.1.1. Field applied insulation for thermal efficiency and condensation control for HVAC piping, ductwork and equipment.

1.1.2. Re-insulation of HVAC piping, ductwork and equipment after asbestos abatement.

1.1.3. Definitions

1.1.3.1. ASJ: All service jacket, white finish facing or jacket.

1.1.3.2. Air conditioned space: Space having air temperature and/or humidity controlled by mechanical equipment.

1.1.3.3. Cold: Equipment or piping handling media at design temperature of 16 degrees C (60 degrees F) or below.

1.1.3.4. Concealed: Piping above ceilings and in chases, interstitial space, and pipe chases.

1.1.3.5. Exposed: Piping and equipment exposed to view in finished areas including mechanical equipment rooms or exposed to outdoor weather. Shafts, chases, interstitial spaces, unfinished attics, crawl spaces and pipe basements are not considered finished areas.

1.1.3.6. Hot: Hot water equipment or piping handling media above 41 degrees C (105 degrees F).

1.1.3.7. Thermal conductance: Heat flow rate through materials.

1.1.3.8. Thermal Conductivity (k): Watt per meter, per degree C (BTU per inch thickness, per hour, per square foot, per degree F temperature difference).

1.1.3.9. Vapor Retarder (Vapor Barrier): A material which retards the transmission (migration) of water vapor. Performance of the vapor retarder is rated in terms of permeance (perms). or the purpose of this specification, vapor retarders shall have a maximum published permeance of 0.1 perms and vapor barriers shall have a maximum published permeance of 0.001 perms.

1.2. **RELATED WORK**

1.2.1. Section: 23 05 00 Common Work Results for HVAC.

1.2.2. Section: 23 31 13 Metal Ducts.

1.3. **QUALITY ASSURANCE**

1.3.1. Comply with OBC requirements for flame spread and smoke development rates.

1.3.2. Specified k factors are at 24 degrees C (75 degrees F) mean temperature unless stated otherwise. For pipe, use insulation manufacturer's published heat flow tables. For

domestic hot water supply and return, run out insulation and condensation control insulation, no thickness adjustment need be made.

1.3.3. All materials shall be compatible and suitable for service temperature, and shall not contribute to corrosion or otherwise attack surface to which applied in either the wet or dry state.

1.3.4. Every package or standard container of insulation or accessories delivered to the job site for use must have a manufacturer's stamp or label giving the name of the manufacturer and description of the material

1.4. **SUBMITTALS**

1.4.1. Submit in accordance with Section: 01 33 23 Shop Drawings, Product Data, and Samples.

1.4.2. Shop Drawings:

1.4.2.1. All information, clearly presented, shall be included to determine compliance with drawings and specifications and ASTM, federal and military specifications.

1.4.2.2. Insulation materials: Specify each type used and state surface burning characteristics.

1.4.2.3. Insulation facings and jackets: Each type used.

1.4.2.4. Insulation accessory materials: Each type used.

1.4.2.5. Manufacturer's installation and fitting fabrication instructions for flexible unicellular insulation.

1.4.2.6. Make reference to applicable specification paragraph numbers for coordination.

1.5. **STORAGE AND HANDLING OF MATERIAL**

1.5.1. Store materials in clean and dry environment, pipe covering jackets shall be clean and unmarred. Place adhesives in original containers. Maintain ambient temperatures and conditions as required by printed instructions of manufacturers of adhesives, mastics and finishing cements.

1.6. **APPLICABLE PUBLICATIONS**

1.6.1. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by basic designation only.

1.6.2. National Fire Protection Association (NFPA):

1.6.2.1. 101-09 Life Safety Code

1.6.2.2. 251-06 Standard methods of Tests of Fire Endurance of Building Construction Materials

1.6.2.3. 255-06 Standard Method of tests of Surface Burning Characteristics of Building Materials

1.6.3. Underwriters Laboratories, Inc (UL):

1.6.3.1. 723 UL Standard for Safety Test for Surface Burning Characteristics of Building Materials with Revision of 08/03

1.6.4. Manufacturer's Standardization Society of the Valve and Fitting Industry (MSS):

1.6.4.1. SP58-2002 Pipe Hangers and Supports Materials, Design, and Manufacture

1.7. **STANDARDS OF ACCEPTANCE**

1.7.1. Owens/Corning, Knauf, Johns Mansville

PART 2 - PRODUCTS

2.1. **DUCTWORK INSULATION**

2.1.1. Application

2.1.1.1. All concealed ductwork, or exposed in mechanical rooms conveying air at temperatures above 30^{O}C or below 18^{O}C and running through heated spaces.
2.1.1.2. All ductwork running through unheated spaces (attics)
2.1.1.3. All exhaust air ductwork 3m upstream of the point of discharge to the outdoors
2.1.1.4. All fresh air supply ductwork
2.1.1.5. All ductwork mounted outdoors
2.1.1.6. All combustion air ductwork

2.1.2. <u>Round Ductwork or Rectangular Ductwork – any side less than 750 mm (30")</u>

2.1.2.1. Insulate ductwork with 40 mm (1½") thick, blanket-type, fiberglass insulation with factory-applied vapor barrier, and 2" stapling and taping flange along one edge. Insulation: ASTM C553, density of 0.75, conductivity of 0.32. Vapor barrier: aluminum foil, permeance of 0.02, and puncture resistance of 50 units. Composite flame spread/ smoke density of 25/50.
2.1.2.2. Apply insulation from outlet of air handling equipment to air distribution equipment
2.1.2.3. Jacket
2.1.2.3.1. Apply for exposed ductwork a zero permeability, all weather, multi-layered laminate coated with a cold weather acrylic adhesive, superior resistance to weathering, mold, UV and extreme environmental conditions. Designed for use as a vapour barrier for insulation cladding and jacketing applications.

2.1.2.3.2. Zero permeability vapour barrier for insulation cladding and jacketing applications
2.1.2.3.3. Cold weather acrylic adhesive applies easily at temperatures as cold as -23°C (-10°F)
2.1.2.3.4. Puncture and Tear resistant
2.1.2.3.5. Self-Adhesive material installs easily with no offsite fabrication required
2.1.2.3.6. Cuts and installs easily on-site, no special tools required
2.1.2.3.7. Flexible, strong, reinforced insulation cladding
2.1.2.3.8. Standard Acceptance: 3M™ VentureClad™ Insulation Jacketing

2.1.3. Round Ductwork - Outdoor

2.1.3.1. Insulate ductwork with 50 mm (2") thick, blanket-type, fiberglass insulation with factory-applied vapor barrier, and 2" stapling and taping flange along one edge. Insulation: ASTM C553, density of 0.75, conductivity of 0.32. Vapor barrier: aluminum foil, permeance of 0.02, and puncture resistance of 50 units. Composite flame spread/ smoke density of 25/50.

2.1.3.2. Jacket
2.1.3.2.1. A zero permeability, all weather, multi-layered laminate coated with a cold weather acrylic adhesive, superior resistance to weathering, mold, UV and extreme environmental conditions. Designed for use as a vapour barrier for insulation cladding and jacketing applications.
2.1.3.2.2. Zero permeability vapour barrier for insulation cladding and jacketing applications
2.1.3.2.3. Cold weather acrylic adhesive applies easily at temperatures as cold as -23°C (-10°F)
2.1.3.2.4. Puncture and Tear resistant
2.1.3.2.5. Self-Adhesive material installs easily with no offsite fabrication required
2.1.3.2.6. Cuts and installs easily on-site, no special tools required
2.1.3.2.7. Flexible, strong, reinforced insulation cladding
2.1.3.2.8. Standard Acceptance: 3M™ VentureClad™ Insulation Jacketing

2.1.4. Rectangular Ductwork – any side larger than 750 mm (30”)

2.1.4.1. In mechanical equipment rooms and all other areas where visible without removing ceilings or opening access panels, insulate ductwork with 40 mm (1 ½” thick) rigid, fiberglass insulation board ASTM C612 Class 2, conductivity of 0.26, density of 3.0. with factory-applied vapor barrier. Vapor barrier: laminated white kraft paper, aluminum foil, glass fiber reinforcement, permeance of 0.02, and puncture resistance of 50 units. Composite flame spread/ smoke density of 25/50.

2.1.4.2. In ceiling spaces, building shafts, and other locations where not visible, insulate ductwork with 1-1/2" thick, blanket-type, fiberglass insulation with factory-

applied vapor barrier, and 2" stapling and taping flange along one edge. Insulation: ASTM C553, density of 0.75, conductivity of 0.23 @75F. Vapor barrier: laminated white kraft paper, aluminum foil, glass fiber reinforcement, permeance of 0.02, and puncture resistance of 50 units. Composite flame spread/ smoke density of 25/50.

2.1.4.3. Jacket

2.1.4.3.1. Apply on exposed ductwork a zero permeability, all weather, multi-layered laminate coated with a cold weather acrylic adhesive, superior resistance to weathering, mold, UV and extreme environmental conditions. Designed for use as a vapour barrier for insulation cladding and jacketing applications.

2.1.4.3.2. Zero permeability vapour barrier for insulation cladding and jacketing applications

2.1.4.3.3. Cold weather acrylic adhesive applies easily at temperatures as cold as -23°C (-10°F)

2.1.4.3.4. Puncture and Tear resistant

2.1.4.3.5. Self Adhesive material installs easily with no offsite fabrication required

2.1.4.3.6. Cuts and installs easily on-site, no special tools required

2.1.4.3.7. Flexible, strong, reinforced insulation cladding

2.1.4.3.8. Standard Acceptance: 3M™ VentureClad™ Insulation Jacketing

2.1.5. <u>Outdoor Rectangular Ductwork – any size</u>

2.1.5.1. Insulate ductwork with 50 mm (2” thick) rigid, fiberglass insulation board with factory-applied vapor barrier. Insulation: ASTM C612 Class 2, conductivity of 0.26, density of 3.0.

2.1.5.2. Vapor barrier: laminated white kraft paper, aluminum foil, glass fiber reinforcement, permeance of 0.02, and puncture resistance of 50 units. Composite flame spread/ smoke density of 25/50.

2.1.5.3. Jacket

2.1.5.3.1. A zero permeability, all weather, multi-layered laminate coated with a cold weather acrylic adhesive, superior resistance to weathering, mold, UV and extreme environmental conditions. Designed for use as a vapour barrier for insulation cladding and jacketing applications.

2.1.5.3.2. Zero permeability vapour barrier for insulation cladding and jacketing applications

2.1.5.3.3. Cold weather acrylic adhesive applies easily at temperatures as cold as -23°C (-10°F)

2.1.5.3.4. Puncture and Tear resistant

2.1.5.3.5. Self Adhesive material installs easily with no offsite fabrication required

2.1.5.3.6. Cuts and installs easily on-site, no special tools required

2.1.5.3.7. Flexible, strong, reinforced insulation cladding

2.1.5.3.8. Standard Acceptance: 3M™ VentureClad™ Insulation Jacketing

2.1.6. Accessories

2.1.6.1. Closure Materials: Butt strips, bands, wires, staples, mastics, adhesives; pressure-sensitive tapes.

2.1.6.2. Support Materials: Hanger straps, hanger rods, saddles, support rings.

2.1.6.3. Contact adhesive: quick-setting, non-flammable fire resistive adhesive to adhere fibrous glass to ducts. Flame spread 15 smoke development 0.

PART 3 - EXECUTION

3.1. **GENERAL REQUIREMENTS**

3.1.1. Required pressure tests of piping and ductwork joints and connections shall be completed and the work approved by the Consultant for application of insulation. Surface shall be clean and dry with all foreign materials, such as dirt, oil, loose scale and rust removed.

3.1.2. Except for specific exceptions, insulate all specified equipment, and piping (pipe, fittings, valves, accessories). Insulate each pipe individually. Do not use scrap pieces of insulation where a full length section will fit.

3.1.3. Insulation materials shall be installed in a first class manner with smooth and even surfaces, with jackets and facings drawn tight and smoothly cemented down at all laps. Insulation shall be continuous through all sleeves and openings, except at fire dampers and duct heaters (NFPA 90A). Vapor retarders shall be continuous and uninterrupted throughout systems with operating temperature 16 degrees C (60 degrees F) and below. Lap and seal vapor barrier over ends and exposed edges of insulation. Anchors, supports and other metal projections through insulation on cold surfaces shall be insulated and vapor sealed for a minimum length of 150 mm (6 inches).

3.1.4. Install vapor stops at all insulation terminations on either side of valves, pumps and equipment and particularly in straight lengths of pipe insulation.

3.1.5. Construct insulation on parts of equipment such as chilled water pumps and heads of chillers, convertors and heat exchangers that must be opened periodically for maintenance or repair, so insulation can be removed and replaced without damage. Install insulation with bolted 1 mm thick (20 gage) galvanized steel or aluminum covers as complete units, or in sections, with all necessary supports, and split to coincide with flange/split of the equipment.

3.1.6. Insulation on hot piping and equipment shall be terminated square at items not to be insulated, access openings and nameplates. Cover all exposed raw insulation with white sealer or jacket material.

3.1.7. Protect all insulations outside of buildings with aluminum jacket using lock joint or other approved system for a continuous weather tight system. Access doors and other items requiring maintenance or access shall be removable and sealable.

3.1.8. Elbows, flanges and other fittings shall be insulated with the same material as is used on the pipe straights.

3.1.9. Hot piping work not to be insulated:

3.1.9.1. Factory pre-insulated components.
3.1.9.2. Over equipment nameplates.
3.1.9.3. Vibration control devices
3.1.9.4. Air chambers, unions, strainers, check valves, flow regulators.
3.1.9.5. Pot feeders, filtration cartridges

3.1.10. Ductwork not to be insulated:

3.1.10.1. Indoor return ductwork
3.1.10.2. Exhaust air ductwork up to 3 m (10 ft) prior to existing the building

3.1.11. Firestop Pipe insulation:

3.1.11.1. Provide firestopping insulation at fire and smoke barriers through penetrations. Fire stopping insulation shall be UL listed.
3.1.11.2. Pipe penetrations requiring fire stop insulation including, but not limited to the following:
3.1.11.2.1. Pipe risers through floors
3.1.11.2.2. Pipe chase walls and floors
3.1.11.2.3. Smoke partitions
3.1.11.2.4. Fire partitions
3.1.11.2.5. Freeze protection of above grade outdoor piping (over heat tracing tape): 20 mm (0.75) thick insulation, for all pipe sizes 75 mm(3 inches) and smaller and 25 mm(1inch) thick insulation for larger pipes. Provide metal jackets for all pipes. Provide where indicated on the drawings

3.1.12. Provide vapor barrier jackets over insulation as follows:

3.1.12.1. All piping and ductwork exposed to outdoor weather.
3.1.12.2. All interior piping and ductwork conveying fluids exposed to outdoor air (i.e. in attics, ventilated (not air conditioned) spaces, etc.

3.1.13. Provide metal jackets over insulation as follows:

3.1.13.1. All HVAC piping and ductwork exposed to outdoor weather.

3.2. **INSULATION INSTALLATION**

3.2.1. Molded Mineral Fiber Pipe and Tubing Covering:

3.2.1.1. Fit insulation to pipe, aligning longitudinal joints. Seal longitudinal joint laps and circumferential butt strips by rubbing hard with a nylon sealing tool to assure a positive seal. Staples may be used to assist in securing insulation. Seal all vapor retarder penetrations on cold piping with a generous application of vapor barrier mastic. Provide inserts and install with metal insulation shields at outside pipe supports. Install freeze protection insulation over heating cable.

3.2.2. Flexible Mineral Fiber Blanket - Ductwork:

3.2.2.1. Adhere insulation to metal with 75 mm (3 inch) wide strips of insulation bonding adhesive at 200 mm (8 inches) on center all around duct. Additionally secure insulation to bottom of ducts exceeding 600 mm (24 inches) in width with pins welded or adhered on 450 mm (18 inch) centers. Secure washers on pins. Butt insulation edges and seal joints with laps and butt strips. Staples may be used to assist in securing insulation. Seal all vapor retarder penetrations with mastic. Sagging duct insulation will not be acceptable. Install firestop duct insulation where required.

3.2.2.2. Blanket insulation shall be tightly sealed at all joints and seams. Insulation shall be cut longer than ductwork perimeter to allow maximum thickness on all areas and avoid excessive compression. All joints shall be over lapped at least 2" and stapled in place. The stapled seams shall be sealed with a minimum 3" wide pressure sensitive tape designed for use with the duct insulation. All breaks in the vapor barrier facing shall also be sealed with the tape. The underside of ductwork 18" or greater in width, and vertical surfaces 48" or greater shall have the insulation additionally secured with mechanical fasteners and speed clips spaced approximately 12" on center. The protruding ends of the fasteners shall be cut off flush after the speed clips are installed, and then sealed with the same tape as specified above.

3.2.2.3. Finished installation shall provide a continuous and effective vapor barrier.

3.2.2.4. Supply air ductwork to be insulated includes main and branch ducts from AHU discharge to room supply outlets, and the bodies of ceiling outlets to prevent condensation. Insulate sound attenuator units, coil casings and damper frames. To prevent condensation, insulate trapeze type supports and angle iron hangers for flat oval ducts that are in direct contact with metal duct.

3.2.3. Rigid Board Mineral Fiber Insulation - Ductwork

3.2.3.1. Apply board on pins spaced not more than 300 mm (12 inches) on center each way, and not less than 75 mm (3 inches) from each edge of board. In addition to

pins, apply insulation bonding adhesive to entire underside of horizontal metal surfaces. Butt insulation edges tightly and seal all joints with laps and butt strips. After applying speed clips cut pins off flush and apply vapor seal patches over clips.

3.2.3.2. Insulation shall be scored, beveled or mitered to provide tight joints and be secured to equipment with bands spaced 225 mm (9 inches) on center for irregular surfaces or with pins and clips on flat surfaces. Use corner beads to protect edges of insulation.

3.2.3.3. For hot equipment: Stretch 25 mm (1 inch) mesh wire, with edges wire laced together, over insulation and finish with insulating and finishing cement applied in one coat, 6 mm (1/4 inch) thick, trowel led to a smooth finish.

3.2.3.4. For cold equipment: Apply meshed glass fabric in a tack coat 1.5 to 1.7 square meter per liter (60 to 70 square feet per gallon) of vapor mastic and finish with mastic at 0.3 to 0.4 square meter per liter (12 to 15 square feet per gallon) over the entire fabric surface.

3.2.4. Duct Wrap for Kitchen Hood Grease Ducts:

3.2.4.1. Not Applicable.

3.2.5. Flexible Elastomeric Cellular Thermal Insulation:

3.2.5.1. Not applicable

3.3. **INSULATION JOINTS**

3.3.1. All insulation joints should be sealed with pressure-sensitive joint sealing tape to match the insulation facing. Rub hard with a plastic sealing tool to affect a tight bond.

3.3.2. Recommended practice: 3" (76mm) wide tape on flat surfaces or where edges are ship-lapped and stapled. Use 5" (102mm) wide tape in lieu of ship-lapping.

3.3.3. All sheet metal joints must be sealed prior to insulating.

3.4. **INSULATION AT DUCT SUPPORTS**

3.4.1. Refer to and conform strictly to insulation and protection jacket manufacturers' instructions.

3.4.2. To properly insulate through a roof top duct support; lift duct off of support, insulate duct through the support, install protection jacket through the support and add an additional layer of protection jacket 6" wide on the bottom and both sides at the point of contact with the support system.

3.4.3. When it is not possible to lift a duct off the rooftop supports, it is necessary to incorporate the support system into the insulation system by encapsulating the supports with insulation. This same system must be used if duct supports are screwed onto the ductwork

3.5. **FIELD-APPLIED JACKET APPLICATION**

3.5.1. Apply PVC jacket on piping insulation where indicated, with 1 inch (25 mm) overlap at longitudinal seams and end joints. Seal with manufacturer's recommended adhesive.

3.5.2. Apply aluminum jacket where indicated (piping and ductwork) and on all piping/ductwork located outdoors, with 2-inch (50 mm) overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel band 12 inches (300 mm) o.c. and at end joints. Provide vapor-barrier jackets. Aluminum jackets shall have seams located below the horizontal plane of the horizontal piping route. Insulate fittings, joints, and valves with insulation of like material and thickness as adjoining pipe, and cover with aluminum jackets.

3.6. **OUTDOOR DUCTWORK – RECTANGULAR**

3.6.1. All roof-top ductwork to must be designed and built with adequate slope (watershed) to prevent ponding water. Ponding water is defined as water that stays in place for greater than 24 hours.

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PART 1 - GENERAL

1.1. **GENERAL**

1.1.1. This section of the specification shall be read in conjunction with and shall be governed by the requirements outlined in Section: 23 05 00 Common Work Results for HVAC.

1.1.2. The Building Automation System (BAS) shall be capable of integrating multiple building functions, including equipment supervision and control, alarm management, energy management, and trend data collection. The BAS shall be the latest generation system available from the installation contractor that has been previously reviewed and accepted by the Board.

1.1.3. Perform an in-depth review of all existing control components associated with the work scope (e.g. controllers, control valves, control dampers, linkages, actuators, pipe and duct sensors, flow switches, etc.).

1.1.4. Immediately report any defective or inoperative components to the Consultant.

1.1.5. Co-ordinate and supervise the work of all sub-contractors required to complete the scope of work as specified in the contract documents.

1.1.6. The Controls Contractor and all sub-contractors shall employ only certified trades persons to carry out all applicable work.

1.1.7. Provide all necessary control wiring and hardware to complete the entire project, including but not limited to, wiring, fittings, connectors, conduits, hangers/supports, box covers, and all other accessories required to ensure complete, safe and fully operational systems.

1.1.8. The BAS at minimum, shall incorporate the following integrated features, functions, and services:

1.1.8.1. Operator information, alarm management and control function.
1.1.8.2. As-built drawings in a separate PDF file, to be retrievable by the Operator at any given time using the BAS interface.
1.1.8.3. Control access
1.1.8.4. Information management, including monitoring, transmission, archiving, retrieval and reporting functions
1.1.8.5. Diagnostic monitoring and reporting of BAS functions
1.1.8.6. Offsite monitoring and management access
1.1.8.7. Energy Management

1.2. **APPROVED CONTROL SYSTEMS**

1.2.1. Johnson Controls (JCI)

1.3. **SCOPE OF WORK**

1.3.1. The general outline of the scope of work includes but is not limited to the following:

1.3.1.1. Remove all existing controls associated with the demolished equipment. Remove all existing actuators, valves, controllers, panels, pneumatic tubing, gauges, sensors, etc.

1.3.1.2. Supply and install all the new BAS components (sensors, actuators, valves, operators, wiring, relays, controllers, panels, etc) required to make the new rooftop unit systems operate in accordance with the sequences indicated on the drawings.

1.3.1.3. Remove any redundant timers and associated wiring and devices controlling the demolished equipment.

1.3.1.4. Update existing programming and user interface as required to match the sequence of operation indicated on the drawings; c/w graphical displays on the Board main server to match the new equipment layout and configuration.

1.3.1.5. Provide all necessary power wiring and hardware to complete the entire project, including but not limited to, wiring, fittings, connectors, conduits, hangers/supports, box covers, BAS control panels, and all other accessories required to ensure complete, safe and fully operational systems. This shall include the power wiring for all the equipment.

1.3.1.6. Make good all surfaces affected by the work.

1.3.1.7. Arrange for Electrical Authority inspection of all electrical work done by the Control Sub- Contractor. Submit the Certificate of Inspection and Product Approval Certificate with the as built documentation.

1.3.1.8. Provide new wiring.

1.3.1.9. Update software and graphical interface as required.

1.3.1.10. All line and low voltage wiring shall be run in EMT metal conduit.

1.3.1.11. Control wiring installed in exposed areas (common areas, mechanical rooms, outdoors) shall be run in IMC rigid metal conduit.

1.3.1.12. Control wiring installed in the ceiling space shall be plenum rated and does not require rigid conduit. Any controls wiring in ceiling spaces is to be run in a cable management tray, and transitions from the tray shall neatly follow the building structure and any wall penetrations must be sleeved in conduit with nylon bushings.

1.3.1.13. Include all wiring, conduit, piping, installation, materials, supervision and labor including calibration, commissioning software programming and data base

generation, and additional work necessary to provide a complete and fully operating system to the approval of the Consultant.

1.3.1.14. Controls sub-contractor shall coordinate with the electrical sub-contractor for the location of breakers and junction boxes from which power to the control's equipment will be provided. The over-all responsibility for providing and coordinating power supply to the controls equipment rests with the mechanical contractor in his capacity as general contractor.

1.3.1.15. The BAS shall be completed in all details not necessarily defined or shown on the drawings but as may be reasonably inferred as necessary to complete each system and provide operating service in an acceptable manner.

1.3.1.16. Upon completion of the installation, all control equipment supplied under this control shall be adjusted to place the system in complete operating condition subject to the Owner's approval. All adjustments shall be made in co-ordination with the TAB sub-contractor responsible for balancing the air and water systems where required.

1.3.1.17. For variable flow systems (air or hydronic), coordinate the final settings of VFDs and pressure differential setpoints with the TAB contractor, to achieve the design flows noted in the equipment schedules.

1.3.1.18. When removing existing equipment, it is the responsibility of the contractor to ensure the integrity of the BAS communication line that must remain intact to ensure the proper function of the remainder of the school BAS system.

1.4. **QUALITY ASSURANCE**

1.4.1. Base bid basis of design products referenced under this Section establish the minimum acceptable standards of product quality, features and performance.

1.4.2. Work of this Section shall be provided by a recognized contractor regularly employed in the installation and wiring of BAS and temperature control system and equipment. The Board will provide a list of acceptable Contractors to bid the work (see Boards list of Pre-Qualified contractors).

1.5. **CODES AND STANDARDS**

1.5.1. Work, materials, and equipment shall comply with the most restrictive of local, state, and federal authorities' codes and ordinances or these plans and specifications. As a minimum, the installation shall comply with current editions in effect 30 days prior to receipt of bids of the following codes:

1.5.1.1. National Electric Code (NEC)

1.5.1.2. International Building Code (IBC)

1.5.1.2.1. Section 719 Ducts and Air Transfer Openings

1.5.1.2.2. Section 907 Fire Alarm and Detection Systems

1.5.1.2.3. Section 909 Smoke Control Systems

1.5.1.3. Division 23 Mechanical

1.5.1.4. International Mechanical Code (IMC)

1.5.1.5. ANSI/ASHRAE 135-2004: Data Communication Protocol for Building Automation and Control Systems (BACNET)

1.6. **APPROVED CONTROL SYSTEM MANUFACTURERS**

1.6.1. Only approved building automation systems will be accepted.

1.7. **EQUIPMENT INSTALLED BY OTHERS (where applicable to project)**

1.7.1. As required, the following equipment shall be supplied as noted and installed by qualified sub trades as part of this contract:

1.7.2. Supply by Mechanical Contractor/Power wiring by Electrical Contractor/Controls wiring by Controls Contractor:

1.7.2.1. Variable Speed Drives, where not integral part of mechanical equipment

1.7.3. Supply Mechanical Contractor / Install – Mechanical Contractor

1.7.3.1. Automatic control dampers (not supplied with packaged equipment)

1.7.4. Supply Mech. Contractor/ install Control Contractor / wired by Control Contractor (not supplied with packaged equipment)

1.7.4.1. Damper Actuators

1.7.5. Supply by Control Contractor / install by Mech. Contractor/ wired by Control Contractor

1.7.5.1. Automatic Controls Valves & Actuators

1.7.5.2. Space temperature sensors

1.7.6. Supply and wired by Control Contractor/ installed by Mechanical Contractor

1.7.6.1. Temperature Sensing Wells

1.7.7. Supply by Mech. Contractor/ installed by Mech. Contractor/ wired by Control, Contractor

1.7.7.1. Air and Hydronic Flow and Pressure sensors

1.7.8. The final completeness of all required components to make equipment operational as indicated on the sequences of operation including wiring, setting and adjustment remains as the final the responsibility of the mechanical contractor acting as the general contractor.

1.8. **SUBMITTALS**

1.8.1. Provide three copies of shop drawings and other submittals on hardware, software, and equipment to be installed or furnished. Drawings should be 11" x 17" prints.

1.8.2. Provide submittals within 6 weeks of contract award.

1.8.3. Begin no work until submittals have been approved for conformity with design intent.

1.8.4. Provide drawings using AutoCAD 2007 (or newer) in following formats: original, pdf and print.

1.8.5. Submittal approval does not relieve Contractor of responsibility to supply sufficient materials to complete work.

1.8.6. Provide submittals on the following:

1.8.6.1. Product Submittals. Clearly indicate applicable data on manufacturer's cut sheets by highlighting or by other means. General catalogs shall not be accepted as cut sheets to fulfill submittal requirements. Select and show submittal quantities appropriate to scope of work.

1.8.6.2. Network Architecture. Riser diagrams showing control network layout, connections to all network devices, communication protocols, network speeds and wire types. Include schematic diagrams of control, communication, and power wiring for central system installation. Show interface wiring to control system.

1.8.6.3. Schematics. Schematic diagram of each controlled system. Label all control points with point names.

1.8.6.4. Wiring diagrams including complete power system, interlocks, control and data communications.

1.8.6.5. Programming code listing for all controllers

1.8.6.6. Manufacturers' data/specification sheets and catalogue cuts for all material and equipment supplied.

1.8.6.7. Floor plan schematic diagrams indicating field sensor and controller locations.

1.8.6.8. Valve Schedule. Indicate system and device designation, product name, manufacturer, and model numbers (both valve and actuator), quantities, sizes, Cv (design and actual), pressure drop, close-off pressure, configuration, ports, and line sizes of each supplied valve and existing control valve.

1.8.6.9. Damper Schedule. Indicate system and device designation, product name, manufacturer, size, and model numbers (both damper and actuator) of each supplied damper/actuator and existing control damper/actuator.

1.8.6.10. Room and Equipment Schedules. Indicate controller type, address, model number, object names, setpoints, and room location.

1.8.6.11. Instrumentation list (Bill of Materials) for each controlled system. List each control system element in a table. Show element name, type of device, manufacturer, model number, and product data sheet number.

1.8.6.12. Manufacturer's description and technical data such as performance curves, product specifications, and installation and maintenance instructions for items listed below and for relevant items not listed below:

1.8.6.12.1. Direct digital controllers (controller panels)

1.8.6.12.2. Transducers and transmitters

1.8.6.12.3. Sensors (include accuracy data)

1.8.6.12.4. Actuators

1.8.6.12.5. Valves

1.8.6.12.6. Dampers

1.8.6.12.7. Relays and switches

1.8.6.12.8. Control panels

1.8.6.12.9. Power supplies

1.8.6.12.10. Batteries

1.8.6.12.11. Operator interface equipment

1.8.6.12.12. Wiring

1.8.6.13. Complete description of control system operation including sequences of operation and points-lists for each control system. Include and reference schematic diagram of controlled system. List I/O points and software points specified in this section. Indicate alarmed and trended points.

1.8.6.14. Wiring diagrams and layouts for each control panel. Show termination numbers.

1.8.6.15. Schematic wiring diagram of each controlled system. Label control elements and terminals. Where a control element is also shown on control system schematic, use the same name.

1.8.6.16. BACnet Protocol Implementation Conformance Statement (PICS) for each submitted type of controller and operator interface.

1.8.7. Schedules

1.8.7.1. Construction Schedule of work provided within one month of contract award, indicating:

1.8.7.1.1. Intended sequence of work items

1.8.7.1.2. Start date of each work item

1.8.7.1.3. Duration of each work item

1.8.7.1.4. Planned delivery dates for ordered material and equipment and expected lead times.

1.8.7.1.5. Milestones indicating possible restraints on work by other trades or situations.

1.8.8. Monthly written status reports indicating work completed and revisions to expected delivery dates. Include updated schedule of work.

1.9. **PROJECT RECORD DOCUMENTS**

1.9.1. Submit three copies of record (as-built) documents upon completion of installation for approval prior to final completion. Submittal shall consist of:

1.9.1.1. As-built versions of submittal shop drawings should be 11" x 17" prints. Provide drawings using AutoCAD 2007 (or newer) in following formats: original, pdf and print.

1.9.1.2. Testing and Commissioning Reports and Checklists. Completed versions of reports, checklists, and trend logs used to meet requirements of this section (Control System Demonstration and Acceptance).

1.9.1.3. An Information sheet that contains:

1.9.1.3.1. School name and address

1.9.1.3.2. A brief description of the control details. i.e. total # of points, list of equipment controls and which panels they a connected to.

1.9.1.3.3. Panel's information i.e. part numbers for panels used and their serial numbers and revision # (if applicable)

1.9.1.3.4. Software version

1.9.1.3.5. Modem telephone number

1.9.1.3.6. Warranty start date and duration

1.9.1.3.7. BAS contractor Name, address, and Phone number

1.9.1.4. Detailed sequence of operation for each controlled system.

1.9.1.5. Control schematics for each system. Including a System Architecture indicating the type and model number for all BAS components, the proposed interconnection and location of all panels, network connection and key peripheral devices (workstations, modems, printers, repeaters, etc)

1.9.1.6. BAS Points List indicating the panel ID, panel location, hardware address, point acronym, point description, field device type, point type (i.e. AO/DO/AI/DI), end device fail position, end device manufacture and model number and wire tag ID.

1.9.1.7. Floor plan with the location of all field mounted control devices.

1.9.1.8. Programming code for all DDC controllers.

1.9.1.9. Wiring diagrams including complete power system, interlocks, control and data communications.

1.9.1.10. Manufacturers' data/specification sheets and catalogue cuts for all material and equipment supplied. This section shall include a summary sheet that indicates all BAS Device, Manufacturers', model number, and quantity of each used on this job.

1.9.1.11. Automatic control valves and dampers where required.

1.9.1.12. Commissioning list including the name of the commissioning agent of the BAS Contractor, his signature and the date of commissioning.

1.9.1.13. Licensed BAS workstation software.

1.9.1.14. BAS programming database stored on a USB memory stick.

1.10. **WARRANTY**

1.10.1. Warrant work as follows:

1.10.1.1. All labour and material (hardware and software) supplied under this contract shall be warranted free from defects for a period of two (2) years after final completion and acceptance. Control system failures during the warranty period shall be adjusted, repaired, or replaced at no additional cost to the Board. The Contractor shall respond to Board request for warranty service within one (1) business day.

1.10.1.2. The final completion and substantial performance date shall be the date of the project turnover meeting.

1.10.1.3. All work shall have a single warranty date, even when the Board has received beneficial use of part of the system in advance of the final completion date.

1.10.1.4. The contractor shall be responsible for correcting any deficiencies, errors or omissions in operating strategies, programming code, system functionality or parameters and operator workstation graphics during the warranty period.

1.11. **BOARD OWNERSHIP OF PROPRIETARY MATERIAL**

1.11.1. Project-specific software and documentation shall become Board's property. This includes, but is not limited to:

1.11.1.1. Record drawings / Documentation

1.11.1.2. Database

1.11.1.3. Application programming code (Two copies and two licenses of Engineering (Program) Tool)

1.11.1.4. All documentation.

1.12. **FACILITIES WITH EXISTING BUILDING AUTOMATION SYSTEM**

1.12.1. Where a facility has an existing BAS that is to be replaced, modified or upgraded, the Controls Contractor shall be responsible for ensuring that the entire system (hardware, programming and system graphics) and all integral parts (new and re-used) are in conformance with all requirements of the specifications outlined herein.

1.12.2. Ensure complete interoperability and compatibility between new and existing DDC systems and components. Provide system firmware and/or hardware upgrades to existing DDC panels/modules where required to ensure a complete working system to the satisfaction of the Consultant.

1.12.3. Where an existing DDC panel is re-used, ensure that sufficient controller memory is present to provide for all specified control functions. Provide memory and/or panel upgrades where required to meet system memory requirements.

1.12.4. Provide new network communication wiring for interconnection between all DDC panels and interfaces.

1.12.5. Existing control wiring and conduits may be re-used only where they comply with the requirements of these specifications and where approved by the Consultant.

1.12.6. Ensure that all re-used DDC panels/modules are upgraded to the latest version of system firmware and system operating software.

1.12.7. Provide complete commissioning and verification of all re-used automation input/output points, end devices and components.

1.12.8. Provide new labeling for wiring, devices and equipment where existing labelling does not meet the requirements of these specifications.

1.13. **CRITICAL ALARM CONTROL SEQUENCES**

1.13.1. Critical alarms are displayed on the plant operator's PC. Critical alarms warn the building operators about critical control problems that require immediate attention.

1.13.2. Critical alarms shall be activated for the following reasons:

1.13.2.1. a boiler or air handler status has not responded to control by the FMS for more than 5 minutes
1.13.2.2. a VFD status has not responded to control by the FMS for more than 5 minutes
1.13.2.3. a heating pump or boiler pump status has not responded to control by the FMS for more than 10 minutes
1.13.2.4. a boiler flame ignition failed
1.13.2.5. a boiler low water cut off has shut the boiler
1.13.2.6. a boiler high limit temperature has shut the boiler
1.13.2.7. FMS low limit temperature controller has tripped
1.13.2.8. FMS supply fan and return fan status has been OFF
1.13.2.9. a space temperature has read below 16OC for more than 10 minutes
1.13.2.10. the radiation supply water temperature is more than 10OC below the supply water low limit for 1 hour during heating season (as determined by OAT)
1.13.2.11. return water temperature in the radiation and glycol loops has dropped 10OC below the low limit.

1.13.3. The remote alarm shall remain in effect until all of the critical alarm conditions are cleared.

1.13.4. The remote alarm shall be disabled when the outside air temperature is above 10OC.

PART 2 - PRODUCTS

2.1. **CONTROLLERS**

2.1.1. General.

2.1.1.1. Provide Building Controllers (BC), Advanced Application Controllers (AAC), Application Specific Controllers (ASC), Smart Actuators (SA), and Smart Sensors (SS) as required to achieve performance specified herein.

2.1.1.2. Every device in the system which executes control logic and directly controls HVAC equipment must conform to a standard BACnet Device profile as specified in ANSI/ASHRAE 135-2004, BACnet Annex L. Unless otherwise specified, hardwired actuators and sensors may be used in lieu of BACnet Smart Actuators and Smart Sensors.

2.1.2. BACNET.

2.1.2.1. Building Controllers (BCs): Each BC shall conform to BACnet Building Controller (B-BC) device profile as specified in ANSI/ASHRAE 135-2004, BACnet Annex L and shall be listed as a certified B-BC in the BACnet Testing Laboratories (BTL) Product Listing.

2.1.2.2. Advanced Application Controllers (AACs). Each AAC shall conform to BACnet Advanced Application Controller (B-AAC) device profile as specified in ANSI/ASHRAE 135-2004, BACnet Annex L and shall be listed as a certified B-AAC in the BACnet Testing Laboratories (BTL) Product Listing.

2.1.2.3. Application Specific Controllers (ASCs). Each ASC shall conform to BACnet Application Specific Controller (B-ASC) device profile as specified in ANSI/ASHRAE 135-2004, BACnet Annex L and shall be listed as a certified B-ASC in the BACnet Testing Laboratories (BTL) Product Listing.

2.1.2.4. Smart Actuators (SAs). Each SA shall conform to BACnet Smart Actuator (B-SA) device profile as specified in ANSI/ASHRAE 135-2004, BACnet Annex L and shall be listed as a certified B-SA in the BACnet Testing Laboratories (BTL) Product Listing.

2.1.2.5. Smart Sensors (SSs). Each SS shall conform to BACnet Smart Sensor (B-SS) device profile as specified in ANSI/ASHRAE 135-2004, BACnet Annex L and shall be listed as a certified B-SS in the BACnet Testing Laboratories (BTL) Product Listing.

2.1.3. BACNET Communication.

2.1.3.1. Each BC shall reside on or be connected to a BACnet network using ISO 8802-3 (Ethernet) Data Link/Physical layer protocol and BACnet/IP addressing.

2.1.3.2. BACnet routing shall be performed by BCs or other BACnet device routers as necessary to connect BCs to networks of AACs and ASCs.

2.1.3.3. Each AAC shall reside on a BACnet network using ISO 8802-3 (Ethernet) Data Link/Physical layer protocol with BACnet/IP addressing, or it shall reside on a BACnet network using the ARCNET or MS/TP Data Link/Physical layer protocol.

2.1.3.4. Each ASC shall reside on a BACnet network using the ARCNET or MS/TP Data Link/Physical layer protocol.

2.1.3.5. Each SA shall reside on a BACnet network using the ARCNET or MS/TP Data Link/Physical layer protocol.

2.1.3.6. Each SS shall reside on a BACnet network using ISO 8802-3 (Ethernet) Data Link/Physical layer protocol with BACnet/IP addressing, or it shall reside on a BACnet network using ARCNET or MS/TP Data Link/Physical layer protocol.

2.2. **COMMUNICATION**

2.2.1. Control products, communication media, connectors, repeaters, hubs, and routers shall comprise a BACnet internetwork. Controller and operator interface communication shall conform to ANSI/ASHRAE Standard 135-2004, BACnet.

2.2.2. Install new wiring and network devices as required to provide a complete and workable control network.

2.2.3. Each controller shall have a communication port for temporary connection to a laptop computer or other operator interface. Connection shall support memory downloads and other commissioning and troubleshooting operations.

2.2.4. Internetwork operator interface and value passing shall be transparent to internetwork architecture.

2.2.5. An operator interface connected to a controller shall allow the operator to interface with each internetwork controller as if directly connected. Controller information such as data, status, and control algorithms shall be viewable and editable from each internetwork controller.

2.2.6. Inputs, outputs, and control variables used to integrate control strategies across multiple controllers shall be readable by each controller on the internetwork. Program and test all cross-controller links required to execute control strategies specified in this section. An authorized operator shall be able to edit cross-controller links by typing a standard object address or by using a point-and-click interface.

2.2.7. Controllers with real-time clocks shall use the BACnet Time Synchronization service. System shall automatically synchronize system clocks daily from an operator-designated controller via the internetwork. If applicable, system shall automatically adjust for daylight saving and standard time.

2.2.8. System shall be expandable to at least twice the required input and output objects with additional controllers, associated devices, and wiring.

2.3. **CONNECTION TO THE BOARD SERVER**

2.3.1. Advise the Board representative of the proposed location of the system router/gateway panel within the facility The controls vendor shall Provide a communication cable (RJ45) between the BAS Controller and the schools HUB under the Board supervision and comply with the Board standard and he shall connect the BAS to the Board server and WAN and confirm that network access to the BAS has been established.

2.4. **BOARD CENTRAL SERVER**

2.4.1. New site databases shall be installed on the designated central TLDSB central server.

2.4.2. Provide written notification to the TLDSB representative prior to installing new site databases to the TLDSB server. Do not install software or make any changes to the server without the written consent of the TLDSB representative.

2.4.3. Set up and configure the server software and area routers (where required) to allow for seamless access to the site BAS via the TLDSB WAN.

2.4.4. Coordinate all activities related to the central server with the TLDSB representatives. Provide the TLDSB with detailed documentation related to any changes made to the server software, settings or protocols

2.5. **LOCAL SERVICE PORTS**

2.5.1. Every DDC panel shall be provided with a local network access port to connect to laptop computer. A user connected to the local access port shall have the same level of system access and functionality as being connected to the site workstation PC.

2.5.2. Where BAS points (4 or more) are located in a mechanical room that does not have a local BAS panel installed, a remote network access port shall be provided. The access port shall be installed in a hinged metal enclosure with key-lock set and lamacoid ID label.

2.6. **COMMUNICATION**

2.6.1. Service Port

2.6.1.1. Each controller shall provide a service communication port for connection to a Portable Operator's Terminal. Connection shall be extended to space temperature sensor ports where shown on drawings.

2.6.2. Signal Management

2.6.2.1. BC and ASC operating systems shall manage input and output communication signals to allow distributed controllers to share real and virtual object information and to allow for central monitoring and alarms.

2.6.3. Data Sharing

2.6.3.1. Each BC and AAC shall share data as required with each networked BC and AAC.

2.6.4. Stand-Alone Operation

2.6.4.1. Each piece of equipment specified in this section Appendix A shall be controlled by a single controller to provide stand-alone control in the event of communication failure. All I/O points specified for a piece of equipment shall be integral to its controller. Provide stable and reliable stand-alone control using default values or other method for values normally read over the network.

2.6.5. Environment

2.6.5.1. Controller hardware shall be suitable for anticipated ambient conditions.

2.6.5.2. Controllers used outdoors or in wet ambient conditions shall be mounted in waterproof enclosures and shall be rated for operation at -29°C to 60°C (-20°F to 140°F).

2.6.5.3. Controllers used in conditioned space shall be mounted in dust-protective enclosures and shall be rated for operation at 0°C to 50°C (32°F to 120°F).

2.6.6. Keypad

2.6.6.1. Provide a local keypad and display for each BC and AAC. Operator shall be able to use keypad to view and edit data. Keypad and display shall require password to prevent unauthorized use. If the manufacturer does not normally provide a keypad and display for each BC and AAC, provide the software and any interface cabling needed to use a laptop computer as a Portable Operator's Terminal for the system.

2.6.7. Real-Time Clock

2.6.7.1. Controllers that perform scheduling shall have a real-time clock

2.6.8. Serviceability

2.6.8.1. Controllers shall have diagnostic LEDs for power, communication, and processor.

2.6.8.2. Wires shall be connected to a field-removable modular terminal strip or to a termination card connected by a ribbon cable.

2.6.8.3. Each BC and AAC shall continually check its processor and memory circuit status and shall generate an alarm on abnormal operation. System shall continuously

check controller network and generate alarm for each controller that fails to respond.

2.6.9. Memory

2.6.9.1. Controller memory shall support operating system, database, and programming requirements.

2.6.9.2. Each BC and AAC shall retain BIOS and application programming for at least 72 hours in the event of power loss.

2.6.9.3. Each ASC and SA shall use nonvolatile memory and shall retain BIOS and application programming in the event of power loss. System shall automatically download dynamic control parameters following power loss.

2.6.9.4. Each controller shall have a min. 25% spare memory to allow for future expansion.

2.6.9.5. Immunity to Power and Noise. Controllers shall be able to operate at 90% to 110% of nominal voltage rating and shall perform an orderly shutdown below 80% nominal voltage. Operation shall be protected against electrical noise of 5 to 120 Hz and from keyed radios up to 5 W at 1 m (3 ft).

2.6.10. Transformer. ASC power supply shall be fused or current limiting and shall be rated at a minimum of 125% of ASC power consumption.

2.7. **INPUT AND OUTPUT INTERFACE**

2.7.1. General. Hard-wire input and output points to BCs, AACs, ASCs, or SAs.

2.7.2. Protection. Shorting an input or output point to itself, to another point, or to ground shall cause no controller damage. Input or output point contact with up to 24 V for any duration shall cause no controller damage.

2.7.3. Digital Inputs. Digital inputs shall monitor the on and off signal from a remote device. Digital inputs shall provide a wetting current of at least 12 mA and shall be protected against contact bounce and noise. Digital inputs shall sense dry contact closure without application of power external to the controller.

2.7.4. Pulse Accumulation Inputs. Pulse accumulation inputs shall conform to binary input requirements and shall accumulate up to 10 pulses per second.

2.7.5. Analog Inputs. Analog inputs shall monitor low-voltage (0-10 Vdc), current (4-20 mA), or resistance (thermistor or RTD) signals. Analog inputs shall be compatible with and field configurable to commonly available sensing devices.

2.7.6. Digital Outputs. Digital outputs shall send an on-or-off signal for on and off control. Building Controller Digital outputs shall have three-position (on-off-auto) override switches and status lights. Outputs shall be selectable for normally open or normally closed operation.

2.7.7. Analog Outputs. Analog outputs shall send a modulating 0-10 Vdc or 4-20 mA signal as required to properly control output devices. Analog outputs shall not drift more than 0.4% of range annually.

2.7.8. Tri-State Outputs. Control three-point floating electronic actuators without feedback with tri-state outputs (two coordinated binary outputs). Tri-State outputs may be used to provide analog output control in zone control and terminal unit control applications such as VAV terminal units, duct-mounted heating coils, and zone dampers.

2.7.9. Universal Inputs and Outputs. Inputs and outputs that can be designated as either binary or analog in software shall conform to the provisions of this section that are appropriate for their designated use.

2.8. **POWER SUPPLIES AND LINE FILTERING**

2.8.1. All electronic equipment shall be complete with all necessary devices to safeguard against voltage spikes, fluctuations, or any other power line anomalies, which might damage the equipment.

2.8.2. Power Supplies. Control transformers shall be UL listed. Furnish Class 2 current-limiting type or furnish over-current protection in primary and secondary circuits for Class 2 service in accordance with NEC requirements. Limit connected loads to 80% of rated capacity.

2.8.3. DC power supply output shall match output current and voltage requirements. Unit shall be full-wave rectifier type with output ripple of 5.0 mV maximum peak-to-peak. Regulation shall be 1.0% line and load combined, with 100-microsecond response time for 50% load changes. Unit shall have built-in over-voltage and over-current protection and shall be able to withstand 150% current overload for at least three seconds without trip-out or failure.

2.8.4. Unit shall operate between 0°C and 50°C (32°F and 120°F). EM/RF shall meet FCC Class B and VDE 0871 for Class B and MILSTD 810C for shock and vibration.

2.8.5. Line voltage units shall be UL recognized and CSA listed.

2.8.6. Power Line Filtering.

2.8.6.1. Provide internal or external transient voltage and surge suppression for workstations and controllers. Surge protection shall have:

2.8.6.1.1. Dielectric strength of 1000 V minimum

2.8.6.1.2. Response time of 10 nanoseconds or less

2.8.6.1.3. Transverse mode noise attenuation of 65 dB or greater

2.8.6.1.4. Common mode noise attenuation of 150 dB or greater at 40-100 Hz

2.9. **AUXILIARY CONTROL DEVICES**

2.9.1. Automatic Control Valves

2.9.1.1. Automatic control valves, shall be globe type valves. Valves and actuators shall be ordered as one factory-assembled and tested unit. Control ball valves will not be accepted.

2.9.1.2. Submit to the Consultant for review the following information for each valve:

2.9.1.2.1. Valve type and size
2.9.1.2.2. Connection type
2.9.1.2.3. Line size
2.9.1.2.4. Valve manufacturer and model number
2.9.1.2.5. Valve flow coefficient
2.9.1.2.6. Design flow
2.9.1.2.7. Pressure drop across valve.
2.9.1.2.8. Maximum close-off pressure
2.9.1.2.9. Actuator manufacturer and model number
2.9.1.2.10. Actuator maximum torque

2.9.1.3. Valves 2" (50mm) and smaller shall be constructed of bronze. Valves 2½" (65mm) and larger shall have iron bodies and bronze mountings.

2.9.1.4. All control valves shall have stainless steel stems. The bronze in bodies and bonnets of all bronze valves shall conform to ASTM B62 for valves rated up to 150psig (1035 Kpa) working pressure and to ASTM B61 for valves rated at 200 psig (1380 Kpa) working pressure. The bodies and bonnets of iron body valves shall conform to ASTM A126, Class B.

2.9.1.5. Control valve discs and seats shall be of bronze for 100 °C or less fluid temperature and of stainless steel for fluid temperatures above 100 °C.

2.9.1.6. The control valves shall have tight shut-off. Flat disk valves are not acceptable.

2.9.1.7. Control valves 2" (50mm) and smaller shall be complete with screwed ends type, except for bronze valves installed in soldered copper piping which shall be complete with soldering ends. Control valves larger than 2" (50mm) shall be complete with flanged end type and proper flanged adapters to copper shall be provided where flanged valves are installed in copper piping.

2.9.1.8. The water control valves shall be sized for a pressure drop of 6 ft. water column or as indicated on mechanical drawings.

2.9.1.9. Each automatic control valve must provide the design output and flow rates at pressure drops compatible with equipment selected.

2.9.1.10. Each automatic control valve must be suitable for the particular system working pressure.

2.9.1.11. Each automatic control valve shall be fitted with a position indicator.

2.9.1.12. All the same type control valves shall be the products of a single manufacturer and have the manufacturer's name, pressure rating and size clearly marked on the outside of the body.

2.9.1.13. All heating valves: default position shall be fully open to the coil.

2.9.1.14. Valves providing two-position service shall be quick opening. Two-way valves shall have replaceable disc or ball.

2.9.1.15. Close-off (Differential) Pressure Rating. Valve actuator and trim shall provide the following minimum close-off pressure ratings.

2.9.1.16. Two-way: 150% of total system (pump) head.

2.9.1.17. Three-way: 300% of pressure differential between ports A and B at design flow or 100% of total system (pump) head.

2.9.1.18. Ports. Valves providing modulating service shall have equal percentage ports.

2.9.1.19. Sizing.

2.9.1.19.1. Two-position service: line size.

2.9.1.19.2. Two-way modulating service: select pressure drop equal to the greatest of twice the pressure drop through heat exchanger (load), 50% of the pressure difference between supply and return mains, or 35 kPa (5 psi).

2.9.1.19.3. Three-way modulating service: select pressure drop equal to the smaller of twice the pressure drop through the coil exchanger (load) or 35 kPa (5 psi).

2.9.1.20. Standard of Acceptance: Belimo

2.9.2. Electric Damper and Valve Actuators.

2.9.2.1. Stall Protection. Mechanical or electronic stall protection shall prevent actuator damage throughout the actuator's rotation.

2.9.2.2. Spring-return Mechanism. Actuators used for power-failure, heating and safety applications shall have an internal mechanical spring-return mechanism or an uninterruptible power supply (UPS), unless otherwise specified

2.9.2.3. Signal and Range. Proportional actuators shall accept a 0-10 Vdc or a 0-20 mA control signal and shall have a 2-10 Vdc or 4-20 mA operating range. (Floating motor actuators may be substituted for proportional actuators in terminal unit applications as described in paragraph 2.6H.)

2.9.2.4. Wiring. 24 Vac and 24 Vdc actuators shall operate on Class 2 wiring.

2.9.2.5. Manual Positioning. Operators shall be able to manually position each actuator when the actuator is not powered. Non-spring-return actuators shall have an external manual gear release. Spring-return actuators with more than 7 N•m (60 in.-lb) torque capacity shall have a manual crank.

2.9.2.6. Standard of Acceptance: Belimo

2.9.3. Positive positioning Relays.

2.9.3.1. Whenever a controller has to proportion more than one motor on a single damper, a positive positioning relay must be used. Whenever a controller has to sequence two or more devices, such as valves or dampers, and for all damper operators on modulating dampers, positive positioning relays must be used. Sequencing by spring ranges alone will not be acceptable. Positive positioning relays have positive mechanical feedback of the controlled device, ratio relays are not acceptable.

2.9.4. Switches

2.9.4.1. Pressure electric switches have diaphragm operated D.P.D.T. snap acting contacts with electrical rating suitable for applications as specified. Pressure electric switches withstand up to 25 psig. And are provided with adjustable cut-in and cutout settings between 3 and 20 psig.

2.9.4.2. Water flow switches are general purpose with a paddle actuated snap acting D.P.D.T. switch rated at 16 amp 120/1/60 A.C.

2.9.4.3. Air proving (differential pressure) switches utilize a differential pressure activated, diaphragm actuated, snap acting D.P.D.T. switch rated at 9.8 amp 120/1/60 A.C. full load. Select differential pressure range to suit the application and setpoint is adjustable. Mount switches with diaphragm in a vertical plane. Switches are CSA approved.

2.9.4.4. Install minimum positioning switches inside local cabinets and lock switches after system balancing.

2.9.4.5. Damper end switches are DPDT, lever operated, activated by damper blade movement and mounted securely on damper frame. Switches have contact ratings of 5A at 120 VAC and are CSA approved.

2.9.5. Electronic Temperature Sensors

2.9.5.1. All mixed air sensors are 1000 ohm nickel, resistance temperature detector (RTD) type with a twenty-five foot averaging element. Accuracy of the RTD sensor shall be +/-0.6°C over a range of –7°C to 49°C (19°F to 120°F).

2.9.5.2. All supply and return air sensors are 1000 ohm nickel RTD type temperature detectors. The sensor probe has a minimum length of 450mm (18"). The accuracy of the sensor is +/-0.6°C over a range of 4°C to 66°C (39°F to 151°F).

2.9.5.3. All space sensors (unless noted differently on drawings) are 1000 ohm nickel RTD type temperature detectors. All space sensors are provided with vented protective covers, local temperature adjustment of +/-1°C from setpoint, built in occupancy sensor. There shall be no temperature display.

2.9.5.4. Local temperature adjustment is by two cap touch buttons and LED scale (no actual temperature gradients will be accepted). The accuracy of the sensor is +/-0.6°C over a range of 4°C to 49°C (39°F to 120°F).

2.9.5.5. All space sensors for vestibules, corridors and other high traffic areas shall be nickel RTD stainless steel plate temperature sensor 100 ohm. Equal to Enercorp.

2.9.5.6. All liquid immersed sensors are 1000 ohm nickel RTD type temperature detectors. Each sensor is provided with a stainless steel well, suitable for the working temperature and pressure of the fluid. The accuracy of the sensor is +/- 0.6°C over a range of –7°C to 49°C (19°F to 120°F).

2.9.5.7. Outdoor air sensor is the 1000 ohm nickel RTD type temperature detector. The RTD sensor is mounted in a weatherproof enclosure. The accuracy of the sensor is +/- 0.6°C over a range of –40°C to 40°C (-40°F to 120°F).

2.9.5.8. All sensor elements other than those for space sensors shall be housed in a factory-made stainless-steel sheath.

2.9.5.9. All sensors shall be calibrated and linearized. Include a written documentation of individual sensors for records.

2.9.6. Duct Averaging Temperature Sensors

2.9.6.1. Provide plenum mounted mixed air temperature averaging type sensors with the following minimum characteristics:

2.9.6.1.1. Constructed of FT6 plenum rated cable incorporating a minimum of 9 temperature sensors encapsulated at equal distances along the 24 foot length of the element. The assembly acts as a single sensor reporting the average temperature from all individual sensors.

2.9.6.1.2. End-to-end accuracy +/- 0.3 °C.

2.9.6.1.3. Mount in a zigzag manner to provide continuous coverage of the entire duct cross-sectional area.

2.9.6.1.4. The use of thermistor type sensors is required.

2.9.6.2. Standard of Acceptance: Greystone

2.9.7. Outdoor Air Temperature Sensors

2.9.7.1. Provide outdoor air temperature sensors with the following minimum characteristics:

2.9.7.1.1. Each sensor shall be 10Kohm thermistor probe

2.9.7.1.2. Provide two sensors for each site.

2.9.7.1.3. Both sensors shall be mounted inside a heavy-duty (blow-proof) solar shield.

2.9.7.1.4. Provide a heavy-duty, metal, wire guard.

2.9.7.2. Standard of Acceptance: Greystone

2.9.8. CO_2 Sensor

2.9.8.1. Provide CO_2 sensors for either wall or duct mounting applications as specified. Provide a heavy duty metal guard to protect the sensor when mounted on walls. Provide the factory-supplied duct mounting kit for all duct mount applications.

2.9.8.2. The sensor shall be microprocessor controlled, fully digital, non-dispersive dual wavelength infrared technology with temperature compensation. The device output shall be 4 to 20mA.

2.9.8.3. The sensor shall have a measurement range of 0 to 3000ppm with an accuracy of +/-25ppm in the 15-30C range. Long term stability shall be no greater than 20 ppm per year. The user selectable range shall be 0 to 1500ppm.

2.9.8.4. Install the sensor in accordance with all manufacturer's instructions. Wall mounted sensors shall be installed at a minimum height of 72" above the finished floor. Sensors shall not be mounted on an outside wall, close to a window, door or in draft areas with direct airflow.

2.9.8.5. The standard of acceptance shall be Greystone

2.9.9. Air Differential Pressure Transmitters

2.9.9.1. Provide differential pressure transmitters to sense differential pressure and convert to a proportional electrical output in applications such as pressure independent Variable Air Volume terminals, S/A duct static pressure, etc. The differential pressure range is selected to match the applications. Select materials suitable for the measured variable, i.e. water and air, and to withstand a minimum of twice the normal working pressure.

2.9.9.2. Each sensor is provided with an industry standard 4-20 mA transmitter, mounted at the sensor not the SCU or panel unless in a finished area. The transmitter and sensor have a combined accuracy of 0.5% of the differential pressure range.

2.9.9.3. Static pressure pickups within finished areas are in blank thermostat cases. Outside static pressure reference heads are complete with a wind baffle cap to eliminate wind pressure effects. The static pressure controller is of the slack diaphragm type with a minimum setpoint range of .01 inches to 6.0 inches W.G.

2.9.10. Liquid Pressure Differential Transmitters

2.9.10.1. The differential pressure transmitter is designed with dual remote sensors that enable it to accept high pressure in ranges up to 500 PSI. All models are rated for overload pressure 2X the maximum fully scale range and burst pressure is 5X the maximum full scaled range. Features include field selectable pressure ranges and output signal types, output reversal and slow damping, port swapping and bidirectional measurements for the most flexible applications. The output signal is factory calibrated and temperature compensated for the highest start-up accuracy.

2.9.10.2. Provide a 3-valve manifold assembly (optional kit to be ordered with sensor) to facilitate sensor servicing and maintenance.

2.9.10.3. Coordinate with the mechanical contractor to provide a pressure tap complete with shut-off valve and “pig tail” tubing (primed with water) for each sensor used to monitor steam pressure.

2.9.10.4. Specifications:

2.9.10.4.1. Power Supply: 24 Vac/dc ± 10% (non-isolated half-wave rectified)

2.9.10.4.2. Output Signal: 4-20 mA sourcing, 0-5/0-10 Vdc (switch selectable)

2.9.10.4.3. LCD: 35 x 15 mm (1.4 x 0.6"), 2-line x 8-character

2.9.10.4.4. Accuracy: ± 1% full scale of selected range (range 4 is ± 2%)

2.9.10.4.5. Stability: ± 0.25% FS typical (1 year)

2.9.10.4.6. Pressure Ranges: 4 per model (menu selectable)

2.9.10.4.7. Media Compatibility: 17-4 PH stainless steel

2.9.10.4.8. Proof Pressure: 2X highest range per model

2.9.10.4.9. Burst Pressure: 20X highest range per model

2.9.10.4.10. Pressure Cycles: > 100 million

2.9.10.4.11. Sensor Operating Range: -40 to 105°C (-40 to 221°F)

2.9.10.4.12. Operating Environment: 0 to 50°C (32 to 122°F), 10 to 90 %RH non-condensing

2.9.10.4.13. Pressure Connection: 1/4" NPT male

2.9.10.4.14. Sensor Housing: IP67

2.9.10.4.15. Remote Sensor Cable: S: FT-6 plenum rated, A: Armored Flexible S/S

2.9.10.4.16. Wiring Connection: 14-22 AWG screw terminal block

2.9.10.4.17. Enclosure: Polycarbonate, UL94-V0, IP65 (NEMA 4X)

2.9.10.5. Standard of Acceptance: Greystone DP series

2.9.11. Control Relays

2.9.11.1. Control relays are DPDT for control of electrical starters and equipment where shown on the Point Schedule.

2.9.11.2. Coil voltage matches the Unit Controller. Contacts are rated at 5A at 120 VAC.

2.9.12. Time Delay Relays

2.9.12.1. Time delay relays shall be solid-state plug-in type, UL listed, and shall have adjustable time delay. Delay shall be adjustable ±100% from setpoint shown. Contact rating, configuration, and coil voltage shall be suitable for application. Provide NEMA 1 enclosure for relays not installed in local control panel.

2.9.12.2. Standard of Acceptance: Enercorp

2.9.13. Override Timers

2.9.13.1. Unless implemented in control software, override timers shall be spring-wound line voltage, UL Listed, with contact rating and configuration required by

application. Provide 0-6 hour calibrated dial unless otherwise specified. Flush mount timer on local control panel face or where shown.

2.9.14. Current Transmitters

2.9.14.1. AC current transmitters shall be self-powered, combination split-core current transformer type with built-in rectifier and high-gain servo amplifier with 4-20 mA two-wire output. Full-scale unit ranges shall be 10 A, 20 A, 50 A, 100 A, 150 A, and 200 A, with internal zero and span adjustment. Unit accuracy shall be ±1% full-scale at 500 ohm maximum burden.

2.9.14.2. Transmitter shall meet or exceed ANSI/ISA S50.1 requirements and shall be UL/CSA recognized.

2.9.14.3. Unit shall be split-core type for clamp-on installation on existing wiring.

2.9.15. Current Transformers

2.9.15.1. AC current transformers shall be UL/CSA recognized and shall be completely encased (except for terminals) in approved plastic material.

2.9.15.2. Transformers shall be available in various current ratios and shall be selected for ±1% accuracy at 5 A full-scale output.

2.9.15.3. Use fixed-core transformers for new wiring installation and split-core transformers for existing wiring installation.

2.9.16. Voltage Transmitters

2.9.16.1. AC voltage transmitters shall be self-powered single-loop (two-wire) type, 4-20 mA output with zero and span adjustment.

2.9.16.2. Adjustable full-scale unit ranges shall be 100-130 Vac, 200-250 Vac, 250-330 Vac, and 400-600 Vac. Unit accuracy shall be ±1% full-scale at 500 ohm maximum burden.

2.9.16.3. Transmitters shall meet or exceed ANSI/ISA S50.1 requirements and shall be UL/CSA recognized at 600 Vac rating.

2.9.17. Voltage Transformers

2.9.17.1. AC voltage transformers shall be UL/CSA recognized, 600 Vac rated, and shall have built-in fuse protection.

2.9.17.2. Transformers shall be suitable for ambient temperatures of 4°C-55°C (40°F-130°F) and shall provide ±0.5% accuracy at 24 Vac and 5 VA load.

2.9.17.3. Windings (except for terminals) shall be completely enclosed with metal or plastic.

2.9.18. Power Monitors

2.9.18.1. Power monitors shall be three-phase type and shall have three-phase disconnect and shorting switch assembly, UL listed voltage transformers, and UL listed split-core current transformers.

2.9.18.2. Power monitors shall provide selectable output: rate pulse for kWh reading or 4-20 mA for kW reading. Power monitors shall operate with 5 A current inputs and maximum error of ±2% at 1.0 power factor or ±2.5% at 0.5 power factor.

2.9.19. Current Switches

2.9.19.1. Current-operated switches shall be self-powered, solid-state with adjustable trip current. Select switches to match application current and DDC system output requirements.

2.9.20. Current Sensors (Analog)

2.9.20.1. Current sensors (CT) shall be used for status monitoring of all motor-driven equipment, where specified.

2.9.20.2. Technical Performance – Output should be only 4-20mA only. Voltage output will not be accepted. End-to-end accuracy +/- 1% of full scale at each range.

2.9.20.3. The current sensors shall be mounted inside the starter cabinets whenever possible. If this is not possible due to space limitation, provide an enclosure to house the sensor.

2.9.20.4. Standard of Acceptance: Enercorp

2.9.21. Status Relays (Solid State)

2.9.21.1. The status relays shall be mounted inside newly provided enclosures mounted near the respective equipment starter cabinets.

2.9.21.2. Standard of Acceptance: Omron Low-Voltage Space Thermostats. Low-voltage space thermostats shall be 24 V, bimetal-operated, mercury-switch type, with adjustable or fixed anticipation heater, concealed setpoint adjustment, 13°C-30°C (55°F-85°F) setpoint range, 1°C (2°F) maximum differential, and vented ABS plastic cover.

2.9.22. Fire stopping and Smoke Seal Materials

2.9.22.1. Asbestos-free elastomeric materials tested, listed and labelled by ULC in accordance with CAN4-S115-M85, for installation in U.L.C. designated firestopping and smoke seal Systems. These Systems shall provide a positive fire, water and smoke seal and a fire- resistance rating (flame, smoke hose stream and temperature) not less than the fire resistance rating of surrounding construction.

2.9.22.2. Materials shall form ULC listed or UL classified assemblies and be compatible with abutting dissimilar materials and finishes.

2.9.22.3. Standard of Acceptance:

2.9.22.3.1. 3M Canada Limited
2.9.22.3.2. A/D Fire Protection System Ltd.
2.9.22.3.3. Fire Stop System

2.9.23. Wall Opening Covering Plates

2.9.23.1. All hole covering plates used on this project shall be stainless steel 18-8 chrome metal alloy, type 302, non-magnetic type for finished areas and pressed steel for unfinished areas. Finish brush marks shall be run in a vertical direction.

2.9.24. Access Doors

2.9.24.1. Access doors installed in unfinished areas shall be constructed of 12 ga prime coated steel and of stainless steel for all areas finished with tile or marble surfaces.
2.9.24.2. Access doors shall be complete with 180? opening door, round safety corners, concealed hinges, screwdriver latches, plaster lock and anchor straps.
2.9.24.3. Access doors shall be 24'x 24' or 12'x 18' as per site condition.
2.9.24.4. Access doors in fire rated construction shall be ULC listed and labeled and of a rating to maintain the fire separation integrity.
2.9.24.5. Standard of Acceptance:
2.9.24.5.1. Zurn Industries Canada Limited
2.9.24.5.2. LeHage Industries Limited
2.9.24.5.3. Acudor Acorn Limited.

2.9.25. Local Control Panels

2.9.25.1. Indoor control panels shall be fully enclosed NEMA 1 construction with hinged door key-lock latch and removable sub-panels. A common key shall open each control panel and sub-panel.
2.9.25.2. Prewire internal and face-mounted device connections with color-coded stranded conductors tie-wrapped or neatly installed in plastic troughs. Field connection terminals shall be UL listed for 600 V service, individually identified per control and interlock drawings, with adequate clearance for field wiring.
2.9.25.3. Each local panel shall have a control power source power switch (on-off) with over current protection.

2.10. **FAIL STATE POSITION OF OUTPUTS**

2.10.1. Unless specified otherwise, configure BAS output points for the following fail state (e.g. device position upon panel failure):

2.10.1.1.	All Fans	OFF
2.10.1.2.	Heating Valves	Full heat to terminal device

2.10.1.3.	Mixing Dampers	Full recirculation air
2.10.1.4.	Face/Bypass Dampers	Full to face
2.10.1.5.	Zone Dampers	Full heat
2.10.1.6.	Heating Pumps	ON (except boiler belly pumps)
2.10.1.7.	Boiler Belly Pumps	OFF
2.10.1.8.	Variable Frequency Drives	ON, minimum programmed speed
2.10.1.9.	Lighting Relays	Last State
2.10.1.10.	Boilers (1 stage)	ON
2.10.1.11.	Boilers (Multi-stage)	LOW ON, HIGH OFF
2.10.1.12.	Cooling Equipment	OFF
2.10.1.13.	Electric Heating	OFF
2.10.1.14.	Domestic Hot Water Pumps	OFF
2.10.1.15.	Roof-top Gas Burners	OFF

2.11. **LAN CABLING**

2.11.1. All LAN cabling shall be Category V as defined by EIA/TIA 568A. The contractor shall test all cabling to verify that 100Mb bandwidth is supported. See commissioning requirements.

2.11.2. Cabling shall be 4 pair, 100 ohm UTP, #24 AWG solid copper conductor PVC insulated, with blue or grey colour coded jacket. FT6 rated cable shall be used unless otherwise required to meet building codes or by-laws.

2.11.3. Data outlets shall be RJ45, 8 pin connectors, with 50 microns of hard gold over nickel, minimum durability of 750 mating cycles and contact pressure of 100 grams per contact. Transmission characteristics shall meet TSB-40 Category V.

2.11.4. Provide one RJ45 data outlet adjacent to each device to be terminated (e.g. workstation PC, DDC panel, hub, etc.) Use a flexible patch cable to connect from the data outlet to the end device. For Delta Controls installations, provide a duplex data outlet at the workstation PC to accommodate the remote security key wiring. LAN cabling shall not be directly terminated to any device.

2.11.5. Provide protection from EMI sources in accordance with CSA-T530 article 4

2.11.6. The contractor shall test all cabling to verify conformance with TIA /EIA TSB-67 - Basic Link Test using a Level 2, bi-directional tester. See commissioning requirements.

2.11.7. Where there are more than 2-90 degree in a conduit run, provide a pull box between sections so that there are two bends or less in any one section.

2.11.8. Where a conduit run requires a reverse bend, between 100 degrees and 180 degrees, insert a pull box at each bend having an angle from 100 degrees to 180 degrees.

2.11.9. Ream all conduit ends and install insulated bushings on each end.

2.11.10. Terminate all conduits that protrude through the structural floor 2" above the concrete base.

2.11.11. Do not use a pull box in lieu of a conduit bend. Align conduits that enter a pull box from opposite ends with each other.

2.11.12. FIBER OPTIC CABLE SYSTEM

2.11.13. Optical Cable. Optical cables shall be duplex 900 mm tight-buffer construction designed for intra-building environments. Sheath shall be UL listed OFNP in accordance with NEC Article 770. Optical fiber shall meet the requirements of FDDI, ANSI X3T9.5 PMD for 62.5/125mm.

2.11.14. Connectors. Field terminate optical fibers with ST type connectors. Connectors shall have ceramic ferrules and metal bayonet latching bodies.

2.12. **WIRING AND RACEWAYS**

2.12.1. General. Provide copper wiring, plenum cable, and raceways as specified in applicable sections of Division 26.

2.12.2. Insulated wire shall use copper conductors and shall be UL listed for 90°C (200°F) minimum service.

PART 3 - EXECUTION

3.1. **EXAMINATION**

3.1.1. Thoroughly examine project plans for control device and equipment locations. Report discrepancies, conflicts, or omissions to Consultant for resolution before starting rough-in work.

3.1.2. Inspect site to verify that equipment can be installed as shown. Report discrepancies, conflicts, or omissions to Consultant for resolution before starting rough-in work.

3.1.3. Examine drawings and specifications for work of others. Report inadequate headroom or space conditions or other discrepancies to Consultant and obtain written instructions for changes necessary to accommodate this Section's work with work of others. Controls Contractor shall perform at his expense necessary changes in specified work caused by failure or neglect to report discrepancies.

3.2. **PROTECTION**

3.2.1. Controls Contractor shall protect against and be liable for damage to work and to material caused by Contractor's work or employees.

3.2.2. Controls Contractor shall be responsible for work and equipment until inspected, tested, and accepted. Protect material not immediately installed. Close open ends of work with temporary covers or plugs during storage and construction to prevent entry of foreign objects.

3.3. **COORDINATION**

3.3.1. Site.

3.3.1.1. Assist in coordinating space conditions to accommodate the work of each trade where work will be installed near or will interfere with work of other trades. If installation without coordination causes interference with work of other trades, Contractor shall correct conditions without extra charge.

3.3.1.2. Coordinate and schedule work with other work in the same area and with work dependent upon other work to facilitate mutual progress.

3.3.2. Life Safety.

3.3.2.1. Duct smoke detectors required for air handler shutdown are provided under Division 16 and/or are existing. Interlock smoke detectors to air handlers for shutdown.

3.3.2.2. Smoke dampers and actuators required for duct smoke isolation are provided under Division 23 and/or are existing. Interlock smoke dampers to air handlers

3.3.2.3. Coordination with Other Controls. Integrate with and coordinate controls and control devices furnished or installed by others as follows.

3.3.2.4. Communication media and equipment shall be provided as specified herein

3.3.2.5. Each supplier of a controls product shall configure, program, start up, and test that product to meet the sequences of operation described herein regardless of where within the contract documents those products are described.

3.3.2.6. Coordinate and resolve incompatibility issues that arise between control products provided under this section and those provided under other sections or divisions of this specification.

3.3.2.7. The contractor is responsible for providing all controls described in the contract documents regardless of where within the contract documents these controls are described.

3.3.2.8. Controls Contractor shall be responsible for integration of control products provided by multiple suppliers regardless of where integration is described within the contract documents.

3.4. **GENERAL WORKMANSHIP**

3.4.1. Install equipment, piping, and wiring or raceway horizontally, vertically, and parallel to walls wherever possible.

3.4.2. Provide sufficient slack and flexible connections to allow for piping and equipment vibration isolation.

3.4.3. Install equipment in readily accessible locations as defined by National Electrical Code (NEC) Chapter 1 Article 100 Part A.

3.4.4. Verify wiring integrity to ensure continuity and freedom from shorts and ground faults.

3.4.5. Equipment, installation, and wiring shall comply with industry specifications and standards and local codes for performance, reliability, and compatibility.

3.5. **FIELD QUALITY CONTROL**

3.5.1. Work, materials, and equipment shall comply with rules and regulations of applicable local, state, and federal codes and ordinances as identified in this section (Codes and Standards).

3.5.2. Continually monitor field installation for code compliance and workmanship quality.

3.5.3. Contractor shall arrange for work inspection by local or state authorities having jurisdiction over the work.

3.6. **EXISTING EQUIPMENT**

3.6.1. Wiring. Interconnecting control wiring shall be removed and shall become Contractor's property unless specifically noted or shown to be reused.

3.6.2. Local Control Panels. Remove and deliver existing control panels to Board.

3.6.3. Repair. Unless otherwise directed, Contractor is not responsible for repair or replacement of existing energy equipment and systems, valves, dampers, or actuators. Notify Consultant in writing immediately of existing equipment that requires maintenance.

3.6.4. Indicator Gauges. Ensure operation of and recalibrate for reasonable accuracy or replace existing gauges.

3.6.5. Room Thermostats. Remove and deliver existing room thermostats to Board unless otherwise noted. Patch and finish holes and marks left by removal to match existing walls.

3.6.6. Electronic Sensors and Transmitters. Remove and deliver existing sensors and transmitters to Board.

3.6.7. Controllers and Auxiliary Electronic Devices. Remove and deliver existing controllers and auxiliary electronic devices to Board.

3.6.8. Damper Actuators, Linkages, and Appurtenances: Remove and deliver existing damper actuators, linkages and appurtenances to Board.

3.6.9. Control Valves. Replace existing control valves with new. Deliver removed control valves to Board.

3.6.10. Existing System Operating Schedule. Existing mechanical system may be disabled during this work.

3.6.11. Maintain fan scheduling using existing or temporary time clocks or control systems throughout the control system installation.

3.6.12. Modify existing starter control circuits if necessary to provide hand-off-auto control of each controlled starter. Furnish new starters or starter control packages as required.

3.6.13. Patch holes and finish to match existing walls.

3.6.14. At Board's request, items to be delivered to Board shall instead be properly disposed of. Hazardous materials shall be disposed in accordance with current regulations and applicable by-laws.

3.7. **WIRING**

3.7.1. Control and interlock wiring and installation shall comply with national and local electrical codes, and manufacturer's recommendations.

3.7.2. NEC Class 1 (line voltage) wiring shall be UL listed in approved raceway as specified by NEC.

3.7.3. All wiring shall be installed in EMT conduit unless specified otherwise. Exposed wiring in finished areas (e.g. corridors, classrooms, gymnasiums, etc.) shall be installed in wiremold (colour to match surrounding area)

3.7.4. Wiring from DDC controllers to sensors and actuators and control system network and low voltage wiring running in accessible ceilings may be installed using LVT cable. Where the ceiling is used as a return air plenum, plenum rated cable shall be used in lieu of LVT cable.

3.7.5. Install EMT and cable at right angles to building lines, securely fastened, and in accordance with current electrical codes and standards.

3.7.6. Power and control wiring shall be copper conductor (RW90). For power wiring, provide #12 AWG (minimum) with a 3% maximum voltage drop in accordance with CEC requirements. Control wiring shall be a minimum of #14 AWG, unless otherwise specified.

3.7.7. The wires smaller than 18 gauge shall not be used and will not be accepted on the project except for: wiring between terminal computer devices, wire in standard communication cables, such as printers and short haul modems, wire used in communication networks, i.e. any cable transferring digital data, using twisted shielded pairs.

3.7.8. The wiring from panels to devices shall be installed without splices. The use of crimp connectors is not allowed when connecting field wiring to sensor or device leads. The use of wire nuts is acceptable in this application.

3.7.9. Power for control system shall not be obtained by tapping into miscellaneous circuits that could be inadvertently switched off. Only dedicated circuit(s) shall power the control system. Provide additional breakers or electrical panels as required.

3.7.10. Mount transformers and other peripheral equipment in panels located in serviceable areas. Provide line-side breakers/fuses for each transformer.

3.7.11. All 120 VAC power for any controls equipment shall be from dedicated circuits. Provide a breaker lock for each breaker used to supply the control system. Update the panel circuit directory.

3.7.12. A dedicated power circuit may be used to power DDC panels and equipment within the same or adjoining mechanical rooms. The use of one power circuit to power DDC panels distributed throughout the building is not acceptable.

3.7.13. The controller may be powered from the equipment that it is directly controlling (i.e. heat pump, rooftop unit) only if the controller controls no other equipment and the power supply to the controller remains energized independently of unit operation or status.

3.7.14. Provide all required code gauge boxes, connectors and other wiring accessories.

3.7.15. For all DC wiring, positive conductors shall be WHITE or RED in colour while negative conductors shall be BLACK in colour.

3.8. **COMMUNICATION WIRING**

3.8.1. Communication wiring shall be low-voltage Class 2 wiring and shall comply with Article 3.7 (Wiring).

3.8.2. Install communication wiring in separate raceways and enclosures from other Class 2 wiring.

3.8.3. During installation do not exceed maximum cable pulling, tension, or bend radius specified by the cable manufacturer.

3.8.4. Verify entire network's integrity following cable installation using appropriate tests for each cable.

3.8.5. Install lightning arrestor according to manufacturer's recommendations between cable and ground where a cable enters or exits a building.

3.8.6. Each run of communication wiring shall be a continuous length without splices when that length is commercially available. Runs longer than commercially available lengths shall have as few splices as possible using commercially available lengths.

3.8.7. Label communication wiring to indicate origination and destination.

3.8.8. Ground coaxial cable according to NEC regulations article on "Communications Circuits, Cable, and Protector Grounding."

3.8.9. BACnet MS/TP communications wiring shall be installed in accordance with ASHRAE/ANSI Standard 135. This includes but is not limited to:

3.8.9.1. The network shall use shielded, twisted-pair cable with characteristic impedance between 100 and 120 ohms. Distributed capacitance between conductors shall be less than 100 pF per meter (30 pF per foot.)

3.8.9.2. The maximum length of an MS/TP segment is 1200 meters (4000 ft) with AWG 18 cable. The use of greater distances and/or different wire gauges shall comply with the electrical specifications of EIA-485.

3.8.9.3. The maximum number of nodes per segment shall be 32, as specified in the EIA 485 standard. Additional nodes may be accommodated by the use of repeaters.

3.8.9.4. An MS/TP EIA-485 network shall have no T connections.

3.9. **FIBER OPTIC CABLE**

3.9.1. During installation do not exceed maximum pulling tensions specified by cable manufacturer. Post-installation residual cable tension shall be within cable manufacturer's specifications.

3.9.2. Install cabling and associated components according to manufacturers' instructions. Do not exceed minimum cable and unjacketed fiber bend radii specified by cable manufacturer.

3.10. **INSTALLATION OF SENSORS**

3.10.1. Install sensors according to manufacturer's recommendations.

3.10.2. Mount sensors rigidly and adequately for operating environment.

3.10.3. Install room temperature sensors on concealed junction boxes properly supported by wall framing.

3.10.4. Air seal wires attached to sensors in their raceways or in the wall to prevent sensor readings from being affected by air transmitted from other areas.

3.10.5. Use averaging sensors in mixing plenums and hot and cold decks. Install averaging sensors in a serpentine manner vertically across duct. Support each bend with a capillary clip.

3.10.6. Install mixing plenum low-limit sensors in a serpentine manner horizontally across duct. Support each bend with a capillary clip. Provide 3 m (1 ft) of sensing element for each 1 m2 (1 ft2) of coil area.

3.10.7. Install pipe-mounted temperature sensors in wells. Install liquid temperature sensors with heat-conducting fluid in thermal wells.

3.10.8. Install outdoor air temperature sensors on north wall at designated location with sun shield complete with metal cover cage.

3.10.9. Differential Air Static Pressure.

3.10.9.1. Supply Duct Static Pressure. Pipe high-pressure tap to duct using a pitot tube. Make pressure tap connections according to manufacturer's recommendations.

3.10.9.2. Return Duct Static Pressure. Pipe high-pressure tap to duct using a pitot tube. Make pressure tap connections according to manufacturer's recommendations.

3.10.9.3. Building Static Pressure. Pipe pressure sensor's low-pressure port to the static pressure port located on the outside of the building through a high-volume accumulator. Pipe high-pressure port to a location behind a thermostat cover.

3.10.9.4. Piping to pressure transducer pressure ports shall contain a capped test port adjacent to transducer.

3.10.9.5. Pressure transducers, except those controlling VAV boxes, shall be located in control panels, not on monitored equipment or on ductwork. Mount transducers in a vibration-free location accessible for service without use of ladders or special equipment.

3.10.9.6. Mount gauge tees adjacent to air and water differential pressure taps. Install shut-off valves before tee for water gauges.

3.10.9.7. Smoke detectors, freezestats, high-pressure cut-offs, and other safety switches shall be hard-wired to de-energize equipment as described in the sequence of operation. Switches shall require manual reset. Provide contacts that allow DDC software to monitor safety switch status.

3.10.9.8. Install humidity sensors for duct mounted humidifiers at least 3 m (10 ft) downstream of the humidifier. Do not install filters between the humidifier and the sensor.

3.11. **FLOW SWITCH INSTALLATION**

3.11.1. Use correct paddle for pipe diameter.

3.11.2. Adjust flow switch according to manufacturer's instructions.

3.12. **ACTUATORS**

3.12.1. General. Mount actuators and adapters according to manufacturer's recommendations.

3.12.2. Electric and Electronic

3.12.2.1. Damper Actuators. Mount actuators directly on damper shaft or jackshaft unless shown as a linkage installation. Link actuators according to manufacturer's recommendations.

3.12.2.2. For low-leakage dampers with seals, mount actuator with a minimum 5° travel available for damper seal tightening.

3.12.2.3. To compress seals when spring-return actuators are used on normally closed dampers, power actuator to approximately 5° open position, manually close the damper, then tighten linkage.

3.12.2.4. Check operation of damper-actuator combination to confirm that actuator modulates damper smoothly throughout stroke to both open and closed positions.

3.12.2.5. Provide necessary mounting hardware and linkages for actuator installation.

3.12.2.6. Valve Actuators. Connect actuators to valves with adapters approved by actuator manufacturer. Actuators and adapters shall be mounted following the actuator manufacturer's recommendations.

3.13. **WARNING LABELS**

3.13.1. Affix permanent warning labels to equipment that can be automatically started by the control system.

3.13.2. Labels shall use white lettering (12-point type or larger) on a red background.

3.13.2.1. Warning labels shall read as follows.

CAUTION

This equipment is operating under automatic control and may start or stop atany time without warning. Switch disconnect to "Off" position before servicing.

3.13.2.2. Affix permanent warning labels to motor starters and control panels that are connected to multiple power sources utilizing separate disconnects.

3.13.2.3. Labels shall use white lettering (12-point type or larger) on a red background.

3.13.2.4. Warning labels shall read as follows.

CAUTION

This equipment is fed from more than one power source with separate disconnects. Disconnect all power sources before servicing.

3.14. **IDENTIFICATION OF HARDWARE AND WIRING**

3.14.1. Label wiring and cabling, including that within factory-fabricated panels, with control system address or termination number at each end within 5 cm (2 in.) of termination.

3.14.2. Label pneumatic tubing at each end within 5 cm (2 in.) of termination with a descriptive identifier.

3.14.3. Permanently label or code each point of field terminal strips to show instrument or item served.

3.14.4. Label control panels with minimum 1 cm (½ in.) letters on laminated plastic nameplates.

3.14.5. Label each control component with a permanent label. Label plug-in components such that label remains stationary during component replacement.

3.14.6. Label room sensors related to terminal boxes or valves with nameplates.

3.14.7. Manufacturers' nameplates and UL or CSA labels shall be visible and legible after equipment is installed.

3.14.8. Label identifiers shall match record documents.

3.14.9. Controllers

3.14.9.1. Provide a separate controller for each AHU or other HVAC system. A DDC controller may control more than one system provided that all points associated with the system are assigned to the same DDC controller. Points used for control loop reset, such as outside air or space temperature, are exempt from this requirement.

3.14.9.2. Building Controllers and Custom Application Controllers shall be selected to provide the required I/O point capacity required to monitor all of the hardware points listed in Appendix A (Sequences of Operation).

3.15. **PROGRAMMING**

3.15.1. Point Naming. Name points as shown on the equipment points list provided with each sequence of operation. See drawings. If character limitations or space restrictions make it advisable to shorten the name, the abbreviations given in Appendix C may be used. Where multiple points with the same name reside in the same controller, each point name may be customized with its associated Program Object number. For example, "Zone Temp 1" for Zone 1, "Zone Temp 2" for Zone 2.

3.15.2. Software Programming. Programming shall provide actions for each possible situation. Graphic- or parameter-based programs shall be documented. Text-based programs shall be modular, structured, and commented to clearly describe each section of the program.

3.15.3. Application Programming. Provide application programming that adheres to sequences of operation specified in in this section. Program documentation or comment statements shall reflect language used in sequences of operation.

3.15.4. System Programming. Provide system programming necessary for system operation.

3.15.5. Operator Interface.

3.15.5.1. Standard Graphics. Provide graphics as specified in this section. Show on each equipment graphic input and output points and relevant calculated points such as indicated on the applicable Points List in this section and on the drawings. Point information on graphics shall dynamically update.

3.15.5.2. Install, initialize, start up, and troubleshoot operator interface software and functions (including operating system software, operator interface database, and third-party software installation and integration required for successful operator interface operation) as described in this section.

3.16. **SEQUENCES OF OPERATION**

3.16.1. As noted on the drawings, together with the list of control points.

3.17. **EQUIPMENT ENCLOSURES AND LOCATIONS**

3.17.1. Provide new enclosures for all field equipment (e.g. DDC panels, transducers, relays, etc.). Enclosures shall be equipped with a hinged door and latch. Provide a BOARD-standard key/lock set for each enclosure.

3.17.2. Mount all enclosures in serviceable areas of mechanical rooms, storage rooms or janitor closets. Obtain written approval of the Consultant prior to mounting any enclosure in ceiling spaces or more than 5’-6” above the finished floor.

3.17.3. All transformers and power supplies for control equipment shall be installed in new dedicated metal cabinets with hinged, lockable covers located in the proximity of their dedicated controller cabinets.

3.17.4. Include within a DDC panel enclosure one 120 VAC duplex receptacle for portable PC power, if the controller cabinet is located further than 5’-0” from the nearest wall receptacle.

3.17.5. Ensure that enclosures are sized to allow for ease of servicing of all equipment contained within. Enclosures containing DDC panels shall be sized to allow for the installation of the maximum allowable number of expansion panels/boards. Do not mount other equipment in a manner that may interfere with the future installation of expansion panels/boards.

3.17.6. For enclosures containing pneumatic transducers or devices, provide one pressure gauge (1½" dial, 0-30psi) for the main air line supply.

3.18. **IDENTIFICATION AND LABELING OF CONTROL EQUIPMENT**

3.18.1. All panels must have a lamicoid tag (min. 3"x1") affixed to the front face indicating panel designation and function (i.e. "BAS Panel 1" or "Relay Panel 3").

3.18.2. All field sensors or devices must have a lamicoid tag (min. 3"x1") attached with tie-wrap or adhesive indicating the point software name and hardware address (i.e. AHU1-MAT, 2.IP4). Tags must be secured by screws where mounted outside of the building, in un-heated spaces, in high humidity areas or where subject to vibration.

3.18.3. Room sensors or other sensors in finished areas must have a lamicoid tag affixed to the front cover. This tag shall be minimum 1"x ½" and indicate the point software name and hardware address.

3.18.4. All devices within a field enclosure shall be identified via a label or tag.

3.18.5. All BAS panel power sources must be identified by a label (min. 3"x1") indicating the source power panel designation and circuit number (i.e. "120vac fed from LP-2A cct #1).

3.18.6. All field control equipment panels fed from more than one power source must have a warning label on the front cover.

3.18.7. All wires shall be identified with the hardware address with a band-type self-adhesive strips or clip-on plastic wire markers at both ends.

3.18.8. All rotating equipment controlled by the BAS shall have a tag or label affixed indicating that the equipment may start without warning.

3.18.9. The location of the phone line manager shall be indicated via a label affixed to the inside cover of the modem enclosure or BAS panel.

3.18.10. All BAS panels will be supplied with a point's list sheet (within a plastic sleeve) attached to the inside door.

3.18.11. The points list shall identify the following for each point:

3.18.11.1. Panel number.
3.18.11.2. Panel location.
3.18.11.3. Hardware address.
3.18.11.4. Software name.
3.18.11.5. Point description.
3.18.11.6. Field device type.
3.18.11.7. Point type (i.e. AI or DO).

3.18.11.8. Device fail position.
3.18.11.9. Device manufacturer.
3.18.11.10. Model number or reference.
3.18.11.11. Wire tag reference.

3.18.12. Provide laminated wiring diagrams for all field mounted relay enclosures. Securely attach to the inside door. Identify power panels and circuit numbers of the equipment being controlled.

3.18.13. Provide laminated wiring diagrams or modify existing equipment wiring diagrams wherever the BAS interfaces to other equipment. (e.g. boilers, chillers, etc.). Securely attach to the inside of the respective control cabinet.

3.18.14. Provide lamacoid labels indicating the required operating sequences, on the boilers and valves, where the boiler plants have manual or automatic isolating valves. Submit actual wording to the Consultant for approval prior to fabrication and installation.

3.18.15. Provide lamacoid or machine labels (as outlined above) for all interposing relays or contactors used in control circuits. The labels shall include the related point software name and hardware address

3.18.16. Provide a lamacoid label to identify the location of concealed devices above the ceiling space. Mount the label on the ceiling grid T-bar or a permanent surface adjacent to the devices. The label shall contain the wording “BAS Devices Above”.

3.18.17. Provide lamacoid labels for all auxiliary HVAC equipment (e.g. force flow cabinets, unit ventilators, unit heater, window AC units, etc.) controlled by the BAS. Mount the labels in the vicinity of the existing thermostat or power switch for the unit. The label shall contain the wording “Under BAS Control”.

3.18.18. Where directed by the Consultant, provide any and all additional labelling, diagrams. schematics or instructions as may be required to facilitate the correct operation and maintenance of controlled building systems.

3.19. **SYSTEM HARDWARE COMMISSIONING**

3.19.1. This contractor shall be responsible for the “end to end” commissioning, testing, verification and start-up of the complete control system hardware including panels, sensors, transducers, end devices, relays and wiring. Where applicable, this shall include any points from an existing and/or re-used automation system in the building.

3.19.2. The contractor shall conduct the hardware commissioning at the facility.

3.19.3. When the site hardware installation is 100% completed (including all labeling and documentation), the contractor shall provide written notification to the Board to schedule the hardware commissioning dates for each facility.

3.19.4. Board reserves the right, at its sole discretion, to discontinue site commissioning at any time if any part of the site hardware installation is found to be incomplete on the date of commissioning. If this occurs, the Contractor shall assume responsibility for any additional costs related to rescheduling of the site commissioning.

3.19.5. The Contractor shall prepare a hardware commissioning report containing the following information and test results:

3.19.5.1. Analog inputs (i.e. temperatures, pressure, etc.) shall be verified with an approved calibration device. All actual temperature readings should be with +/- 1C of the readings observed at the workstation. Record calibration adjustments and settings.

3.19.5.2. Analog outputs shall be verified by manually commanding the output channel from the operator workstation to two or more positions within the 0-100% range and verifying the actual position of the actuator or device. All devices shall operate over their entire 0-100% range from a minimum control range of 10-90%. Record the actual output scale range (channel output voltage versus controller command) for each analogue end device

3.19.5.3. Digital outputs shall be verified by witnessing the actual start/stop operation of the equipment under control.

3.19.5.4. Digital inputs shall be verified by witnessing the status of the input point as the equipment is manually cycled on and off.

3.19.5.5. Identify any existing equipment (valves, dampers, fan starters, etc..) that are inoperative or require maintenance or repair.

3.19.5.6. The BAS field panel power source shall be toggled on and off to ensure reboot functionality and power down memory retention of all parameters. During the power down test, all controlled system outputs shall go to their fail-safe position.

3.19.5.7. The hardware commissioning report must be signed and dated by the Contractor's technician performing the tests and participating Board representative.

3.19.5.8. Include with the hardware commissioning report a site floor plan indicating the location of all equipment installed in concealed or recessed locations (e.g. interposing relays in ceiling spaces).

3.19.5.9. Provide testing of all LAN cabling to ensure that 100Mb bandwidth is supported.

3.19.5.10. Verify conformance with TIA /EIA TSB-67 - Basic Link Test using a Level 2, bi-directional tester. Provide all equipment necessary to carry out the required tests.

3.19.5.11. The Contractor shall prepare a software commissioning report containing the following information and test results:

3.19.6. Alarms and Interlocks.

3.19.6.1. Check each alarm with an appropriate signal at a value that will trip the alarm.

3.19.6.2. Trip interlocks using field contacts to check logic and to ensure that actuators fail in the proper direction.

3.19.6.3. Tests interlock actions by simulating alarm conditions to check initiating value of variable and interlock action.

3.19.7. Record all out-of-season or unverified points in the commissioning report as "non-commissioned".

3.19.8. Verify PID loop tuning parameters by applying a step change to the current setpoint and observing the response of the controlled device. Setpoint should be reached in an acceptable period of time without excessive cycling or hunting of the controlled device. Provide a graph of the trend response to setpoint change for important controlled devices (e.g. valves 1-inch or larger, dampers on major air handlers, etc.)

3.19.9. Provide confirmation that a series of test alarms has been successfully received at a designated remote monitoring workstations.

3.19.10. The software commissioning report must be signed and dated by the Contractor's technician performing the tests and participating Board representative.

3.19.11. At the completion of site commissioning, submit four (4) copies of each the hardware and software commissioning reports to the Board.

3.20. **SUBSTANTIAL COMPLETION INSPECTION**

3.20.1.1. At the completion of the site hardware inspection, the Contractor shall test and verify that the system programming, graphics and alarm software is operating correctly and is in compliance all requirements of the specifications.

3.20.1.2. The Contractor shall provide written notification to the Board that the site is ready for the Substantial Completion Inspection by the Consultant.

3.20.1.3. At the conclusion of the Substantial Completion Inspection, the Consultant shall issue a comprehensive site deficiency report to the Contractor for his immediate action.

3.20.1.4. The Contractor shall correct all items noted in the site deficiency report within ten (10) business days of receipt.

3.20.1.5. The Contractor shall provide written notification to the Board that all items on the Consultant's site deficiency report have been corrected.

3.21. **CONTROL SYSTEM DEMONSTRATION AND ACCEPTANCE**

3.21.1. Demonstration. Prior to acceptance, perform the following performance tests to demonstrate system operation and compliance with specification after and in addition to tests specified above. Provide Consultant with log documenting completion of Substantial Completion Inspection.

3.21.2. Consultant and Board Representative will be present to observe and review system demonstration. Notify Consultant and Board Representative at least 10 days before system demonstration begins.

3.21.3. Demonstration shall follow process submitted and approved. Complete approved checklists and forms for each system as part of system demonstration.

3.21.4. Demonstrate actual field operation of each sequence of operation as specified herein. Provide at least two persons equipped with two-way communication. Demonstrate calibration and response of any input and output points requested by Consultant. Provide and operate test equipment required to prove proper system operation.

3.21.5. Demonstrate compliance with sequences of operation through each operational mode.

3.21.6. Demonstrate complete operation of operator interface.

3.21.7. Demonstrate each of the following.

3.21.7.1. DDC loop response. Supply graphical trend data output showing each DDC loop's response to a setpoint change representing an actuator position change of at least 25% of full range. Trend sampling rate shall be from 10 seconds to 3 minutes, depending on loop speed. Each sample's trend data shall show setpoint, actuator position, and controlled variable values. Consultant will require further tuning of each loop that displays unreasonably under- or over-damped control.

3.21.7.2. Building fire alarm system interface.

3.21.7.3. Trend logs for each system. Trend data shall indicate setpoints, operating points, valve positions, and other data as specified in the points list provided with each sequence of operation. Each log shall cover three 48-hour periods and shall have a sample frequency not less than 10 minutes or as specified on its points list. Logs shall be accessible through system's operator interface and shall be retrievable for use in other software programs.

3.21.8. Tests that fail to demonstrate proper system operation shall be repeated after Contractor makes necessary repairs or revisions to hardware or software to successfully complete each test.

3.21.9. Acceptance.

3.21.9.1. After tests described in this specification are performed to the satisfaction of both Consultant and Board, Consultant will accept control system as meeting

completion requirements. Consultant may exempt tests from completion requirements that cannot be performed due to circumstances beyond Contractor's control. Consultant will provide written statement of each exempted test. Exempted tests shall be performed as part of warranty.

3.21.10. System shall not be accepted until completed demonstration forms and checklists are submitted and approved as required.

3.22. **CLEANING**

3.22.1. Each day clean up debris resulting from work. Remove packaging material as soon as its contents have been removed. Collect waste and place in designated location.

3.22.2. On completion of work in each area, clean work debris and equipment. Keep areas free from dust, dirt, and debris.

3.22.3. On completion of work, check equipment furnished under this section for paint damage. Repair damaged factory-finished paint to match adjacent areas. Replace deformed cabinets and enclosures with new material and repaint to match adjacent areas.

3.23. **TRAINING**

3.23.1. Provide training for a designated staff of Board's representatives. Training shall be provided via self-paced training, web-based or computer-based training, classroom training, or a combination of training methods.

3.23.2. Training shall enable students to accomplish the following objectives.

3.23.2.1. Proficiently operate system.
3.23.2.2. Understand control system architecture and configuration.
3.23.2.3. Understand DDC system components.
3.23.2.4. Understand system operation, including DDC system control and optimizing routines (algorithms)
3.23.2.5. Operate workstation and peripherals
3.23.2.6. Log on and off system
3.23.2.7. Access graphics, point reports, and logs
3.23.2.8. Adjust and change system set-points, time schedules, and holiday schedules
3.23.2.9. Recognize common HVAC system malfunctions by observing system graphics, trend graphs, and other system tools
3.23.2.10. Understand system drawings and Operation and Maintenance manual
3.23.2.11. Understand job layout and location of control components
3.23.2.12. Access data from DDC controllers
3.23.2.13. Operate portable operator's terminals
3.23.2.14. Create and change system graphics

3.23.2.15. Create, delete, and modify alarms, including configuring alarm reactions
3.23.2.16. Create, delete, and modify point trend logs (graphs) and multi-point trend graphs
3.23.2.17. Configure and run reports
3.23.2.18. Add, remove, and modify system's physical points
3.23.2.19. Create, modify, and delete application programming
3.23.2.20. Add operator interface stations
3.23.2.21. Add a new controller to system
3.23.2.22. Download firmware and advanced applications programming to a controller
3.23.2.23. Configure and calibrate I/O points
3.23.2.24. Maintain software and prepare backups
3.23.2.25. Interface with job-specific, third-party operator software
3.23.2.26. Add new users and understand password security procedures

3.23.3. Divide presentation of objectives into three sessions (1-13, 14-23, and 24-26). Participants will attend one or more of sessions, depending on knowledge level required.

3.23.3.1. Day-to-day Operators (objectives 1-13)
3.23.3.2. Advanced Operators (objectives 1-13 and 14-23)
3.23.3.3. System Managers and Administrators (objectives 1-13 and 14-26)
3.23.3.4. Provide course outline and materials Provide one copy of training material per student.
3.23.3.5. Instructors shall be factory-trained and experienced in presenting this material.
3.23.3.6. Perform classroom training using a network of working controllers representative of installed hardware.

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PART 1 - GENERAL

1.1. **RELATED DOCUMENTS**

1.1.1. Drawings and general provisions of the Contract, including General Conditions apply to this Section.

1.1.2. Specifications throughout all Divisions of the Project Manual are directly applicable to this Section, and this Section is directly applicable to them.

1.2. **SUMMARY**

1.2.1. This section covers the complete natural gas system installation, within and to five (5) feet beyond building perimeter unless noted otherwise on Contract Drawings, including but not limited to piping, regulators, unions, valves, installation, testing and other normal parts that make the systems complete, operable, code compliant and acceptable to the authorities having jurisdiction.

1.3. **REFERENCE STANDARDS**

1.3.1. The latest published edition of a reference shall be applicable to this Project unless identified by a specific edition date.

1.3.2. All reference amendments adopted prior to the effective date of this Contract shall be applicable to this Project.

1.3.3. All materials, installation and workmanship shall comply with the applicable requirements and standards addressed within the following references:

1.3.3.1. CSA B-149.1 Latest Edition
1.3.3.2. NFPA 54, National Fuel Gas Code, Latest Edition.
1.3.3.3. American Society of Mechanical Engineers (ASME): (Copyrighted Society)
1.3.3.3.1. A13.1-96 Scheme for Identification of Piping Systems
1.3.3.3.2. B16.3 98 Malleable Iron Threaded Fittings ANSI/ASME
1.3.3.3.3. B16.9 01 Factory-Made Wrought Steel Buttwelding Fittings
1.3.3.3.4. B16.11 01 Forged Steel Fittings, Socket-Welding and Threaded ANSI/ASME
1.3.3.3.5. B16.15-85(R 1994) Cast Bronze Threaded Fittings ANSI/ASME
1.3.3.3.6. B31.8-01 Gas Transmission and Distribution Piping Systems ANSI/ASME
1.3.3.4. American Society for Testing and Materials (ASTM):
1.3.3.4.1. A47-99 Ferritic Malleable Iron Castings Revision 1989
1.3.3.4.2. A53-02 Pipe, Steel, Black And Hot-Dipped, Zinc-coated Welded and Seamless
1.3.3.4.3. A183-83(R1998) Carbon Steel Track Bolts and Nuts
1.3.3.4.4. A536-84(R1999) E1 Ductile Iron Castings

1.3.3.4.5. A733-03 Welded and Seamless Carbon Steel and Austenitic Stainless Steel Pipe Nipples

1.3.3.4.6. B687-99 Brass, Copper, and Chromium-Plated Pipe Nipples

1.4. **QUALITY ASSURANCE**

1.4.1. All materials, equipment and Work shall meet or exceed all applicable federal, state and local requirements and conform to codes and ordinances of authorities having jurisdiction.

1.4.2. Valves: Manufacturer’s name, size, standards compliance and pressure rating clearly marked on outside of valve body.

1.4.3. Welding Materials and Procedures: Conform to ASME Code and applicable state labor regulations.

1.4.4. Manufacturer Qualifications: Company specializing in manufacturing the Products specified in this section with minimum three (3) years documented experience.

1.5. **SUBMITTALS**

1.5.1. Product Data:

1.5.1.1. Provide code and standards compliance verification, manufacturer's product data and ratings on pipe materials, pipe fittings, regulators, valves and accessories.

1.5.1.2. Manufacturer's Literature and Data:

1.5.1.2.1. Pipe & Fittings.

1.5.1.2.2. Valves.

1.5.1.2.3. Strainers.

1.5.1.2.4. All items listed in Part 2 - Products.

1.5.2. Record Documents:

1.5.2.1. Submit test reports and inspection certification for all natural gas systems installed under this Contract.

1.5.2.2. Submit manufacturer's data reports for all material used in coating and wrapping.

1.5.2.3. Submit welder’s certifications prior to any shop or field fabrication. Welder’s certifications shall be current within six (6) months of submission.

1.5.2.4. Record actual locations of valves, regulators, etc. and prepare valve charts.

1.5.2.5. Provide full written description of manufacturer’s warranty.

1.5.3. Operation and Maintenance Data:

1.5.3.1. Include installation instructions, spare parts lists, exploded assembly views manufacturer’s recommended maintenance.

1.6. **DELIVERY, STORAGE AND HANDLING**

1.6.1. Accept valves on site in shipping containers with labeling in place, inspect for damage and store with a minimum of handling. Store plastic piping under cover out of direct sunlight. Do not store materials directly on the ground.

1.6.2. Provide temporary protective coating on cast iron and steel valves.

1.6.3. Provide temporary end caps and closures on piping and fittings. Maintain in place until installation.

1.6.4. Protect piping systems from entry of foreign materials by temporary covers, completing sections of the work and isolating parts of completed system.

1.7. **EXTRA MATERIALS**

1.7.1. Provide one (1) plug valve wrench for every ten (10) plug valves sized 50 mm (2 inches) and smaller, minimum of one. Provide each plug valve sized 65 mm (2½ inches) and larger with a wrench incorporating a setscrew.

PART 2 - PRODUCTS

2.1. **GENERAL**

2.1.1. All materials shall meet or exceed all applicable referenced standards, federal, state and local requirements, and conform to codes and ordinances of authorities having jurisdiction.

2.1.2. Natural gas pressures shall not exceed 34.5 kPa (5 psi) gauge on customer side of the meter.

2.1.3. Pipe joint compound shall be lead-free, non-toxic, non-hardening, insoluble in the presence of natural gas and compliant with ANSI/NSF 61. Temperature service range of -15 degrees F to +400 degrees F.

2.2. **PIPING**

2.2.1. <u>Above Ground Piping Outside of Building (Including roof):</u>

2.2.1.1. Piping 50 mm (2 inches) and smaller shall be seamless Schedule 40 black steel, ASTM A106 or ASTM A53 Type "S", Grade A or B, with Class 150 black malleable iron threaded fittings conforming to ASME B16.3.

2.2.1.2. Piping 65 mm (2½ inches) and larger shall be Type "S" seamless or Type "E" electric resistance welded Schedule 40 black steel, ASTM A53, Grade A or B, with Schedule 40 wrought carbon steel fittings, ASTM A 234 and butt weld joints.

2.2.1.3. Provide field applied primer and outdoor-grade yellow epoxy paint coating on all pipe and fittings. Galvanizing shall not be considered adequate protection.

2.2.2. Above Ground Piping Exposed Inside of Building:

2.2.2.1. Piping 50 mm (2 inches) and smaller shall be seamless Schedule 40 black steel, ASTM A106 or ASTM A53 Type "S", Grade A or B, with Class 150 black malleable iron threaded fittings conforming to ASME B16.3.

2.2.2.2. Piping 65 mm (2½ inches) and larger shall be Type "S" seamless or Type "E" electric resistance welded Schedule 40 black steel, ASTM A53, Grade A or B, with Schedule 40 wrought carbon steel fittings, ASTM A 234 and butt weld joints.

2.2.2.3. Provide field applied primer and yellow epoxy paint coating on all pipe and fittings. Galvanizing shall not be considered adequate protection.

2.3. **EXCEPTIONS:**

2.3.1. All exposed piping 50 mm (2 inches) and smaller located within areas utilized as return air plenums shall have welded joints with Schedule 40 socket welded forged steel fittings conforming to ASME B16.11.

2.3.2. All exposed piping 50 mm (2 inches) and smaller serving laboratories from main natural gas riser to each emergency shut-off valve shall have welded joints with Schedule 40 socket welded forged steel fittings conforming to ASME B16.11.

2.3.3. Above Ground Piping Concealed Inside of Building (Includes above all ceilings, within partitions, within chases, and all non-accessible locations):

2.3.3.1. Piping 50 mm (2 inches) and smaller shall be seamless Schedule 40 black steel, ASTM A106 or ASTM A53 Type "S", Grade A or B, with welded joints with Schedule 40 socket welded forged steel fittings conforming to ASME B16.11.

2.3.3.2. Piping 65 mm (2½ inches) and larger shall be Type "S" seamless or Type "E" electric resistance welded Schedule 40 black steel, ASTM A53, Grade A or B, with Schedule 40 wrought carbon steel fittings, ASTM A 234 and butt weld joints.

2.4. **VALVES**

2.4.1. All valves shall be designed, manufactured and approved for natural gas service.

2.4.2. Standards of Acceptance: Nibco, Magnatrol, Emerson

2.4.3. Line Shut-off Valves sizes 50 mm (2 inches) and smaller shall be iron body lubricated plug valve conforming to ASTM-A-126, U.L. Listed and A.G.A. Approved for natural gas service with threaded ends, wrench operation, rated for 200 WOG service pressure and –20 to 200 degrees F.

2.4.4. Line Shut-off Valves sizes 65 mm (2½ inches) and larger shall be iron body lubricated plug valve conforming to ASTM-A-126, U.L. Listed and A.G.A. Approved for natural gas service with flanged ends, wrench operation, rated for 200 WOG service pressure and –20 to 200 degrees F.

2.4.5. Appliance/Equipment Shut-off Valves at local connections sizes 2 inches and smaller shall be bronze body, full port ball or butterfly type, U.L. Listed and A.G.A. Approved for natural gas service with threaded ends, quarter turn lever handle operation, rated for 175 W.O.G. service pressure and 30 to 275 degrees F.

2.4.6. Manual Emergency Shut-off Valves sizes 2 inches and smaller shall be bronze body, full port ball or butterfly type, U.L. Listed and A.G.A. Approved for natural gas service with threaded ends, quarter turn lever handle operation, rated for 175 W.O.G. service pressure and 30 to 275 degrees F.

2.4.7. Automatic Emergency Shut-off Valves shall be U.L. Listed F.M. Approved for natural gas service, 2-way electrically tripped solenoid type; fail safe closed; manual reset; Type 1 solenoid enclosure; NBR seals and disc; stainless steel core tube and springs; copper coil.

2.5. **STRAINERS**

2.5.1. Provide on high pressure side of pressure reducing valves, on inlet side of indicating and control instruments and equipment subject to sediment damage and where shown on drawings. Strainer element shall be removable without disconnection of piping.

2.5.2. Gas Lines: "Y" type with removable mesh lined brass strainer sleeve.

2.5.3. Body: Smaller than 80 mm (3 inches), brass or bronze; 80 mm (3 inches) and larger, cast iron or semi steel.

2.6. **PRESSURE REGULATORS**

2.6.1. All pressure regulators shall be designed, manufactured and approved for natural gas service.

2.6.2. Vent all pressure regulators to the outdoors, in accordance with TSSA and CSA-B-149.1 requirements. Terminate vents with approved caps and insect screens as per TSSA requirements and CSA B-149.1 provisions.

2.6.3. Segregate regulators vents by pressure levels; do not gang-vent vents from regulators serving different pressure gas piping. Size common vents as per CSA B-149.1 provisions.

2.6.4. Pressure regulators for individual service lines shall be capable of reducing distribution line pressure to pressures required for users. Pressure relief shall be set at a lower pressure than would cause unsafe operation of any connected user. Regulator shall have

a single port with orifice diameter no greater than that recommended by manufacturer for the maximum gas pressure at the regulator inlet. Regulator vent valve shall be of resilient materials designed to withstand flow conditions when pressed against valve port. Regulator shall be capable of limiting build-up of pressure under no-flow conditions to 50 percent or less of the discharge pressure maintained under flow conditions. Commercial grade diaphragm type with internal relief valve, vent valve, cast iron body, Buna-N diaphragm.

2.6.5. Install pressure gauge adjacent to and downstream of each line pressure regulator.

2.6.6. Standard of Acceptance: Rockwell, Fisher.

2.7. **UNIONS**

2.7.1. Unions in 2 inches and smaller in ferrous lines shall be right and left hand nipple/coupling assembly, or ASME B16.39, Class 150, malleable iron with brass-to-iron seat, ground joint, and threaded ends, 2-1/2 inches and larger shall be ground flange unions. Companion flanges on lines at various items of equipment, machines and pieces of apparatus may serve as unions to permit disconnection of piping.

2.7.2. Unions connecting ferrous pipe to copper or brass pipe shall be dielectric type.

2.7.3. Above grade flexible stainless steel appliance/equipment connectors shall conform with AGA under the ANSI Z21.69 Standard. Hose shall be braided stainless steel with a polyolefin heat-shrink tubing with high flame-retardant qualities. Hose shall be equipped with malleable iron unions and spring loaded brass quick-link couplings. An easily accessible manual shut-off valve shall be installed ahead of all hose connections. Specify T&S Brass "Safe-T-Link" or approved equal.

2.8. **FLANGES**

2.8.1. All 150 lb. and 300 lb. ANSI flanges shall be domestically manufactured, weld neck forged carbon steel, conforming to ANSI B16.5 and ASTM A 181 Grade I or II or A 105 71. Slip on flanges shall not be used. Each fitting shall be stamped as specified by ANSI B16.9 and, in addition, shall have the laboratory control number stenciled on each fitting for ready reference as to physical properties and chemical composition of the material. Complete test reports may be required for any fitting selected at random.

2.8.2. Flanges which have been machined, remarked, painted or otherwise produced domestically from imported forges will not be acceptable. Flanges shall have the manufacturer's trademark permanently identified in accordance with MSS SP 25. Contractor shall submit data for firm certifying compliance with these Specifications.

2.8.3. Bolts used shall be carbon steel bolts with semi finished hexagon nuts of American Standard Heavy dimensions. All thread rods will not be an acceptable for flange bolts.

Bolts shall have a tensile strength of 60,000 psi and an elastic limit of 30,000 psi. Flat-faced flanges shall be required to match flanges on pumps, check valves, strainers, etc. Only one manufacturer of weld flanges will be approved for each project.

2.8.4. All flanges shall be gasketed. Contractor shall place gasket between flanges of flanged joints. Gaskets shall fit within the bolt circle on raised face flanges and shall be full face on flat face flanges. Gaskets shall be cut from 1/16 inch thick, non metallic, non asbestos gasket material suitable for operating temperatures from 150 degrees F to +75 degrees F, Klingersil C-4400, Manville Style 60 service sheet packing, or approved equal.

2.9. **LABORATORY NATURAL GAS PIPING**

2.9.1. All natural gas piping serving labs from main natural gas riser shall be routed exposed to view below ceiling and painted yellow.

2.9.2. Install emergency gas shut-off valve in each line serving individual laboratory rooms. Locate shut-off actuator within lab area adjacent to each room exit at 1,500 mm (60 inches) above finished floor. Location of emergency shut-off shall be accessible to occupants for shutting off the natural gas supply under emergency conditions.

2.9.3. Gas piping joints shall be welded from main natural gas riser to each emergency shut-off valve. Piping from the emergency shutoff valve to the outlets shall be assembled with threaded fittings provided all joints are exposed to view or within the confines of laboratory furniture.

2.9.4. Install flexible stainless steel appliance/equipment connector at each fume hood and biological safety cabinet requiring natural gas service. Connectors shall not be concealed within or extended through wall, floor or partition and shall be located entirely in the same room as the connected equipment. Provide an accessible shut-off valve not less than the nominal size of the equipment connector, immediately ahead of the connector.

2.10. **EXPANSION COMPENSATORS**

2.10.1. For piping 50 mm (2”) and less: refer to details shown in CSA-B149.1

2.10.2. For Piping 65 mm (2½”) and larger:

2.10.2.1. CGA-Approved Flexible Hose Expansion Loops for Fuel Applications

2.10.2.1.1. Provide flexible hose expansion loop(s) as required to accommodate any thermal expansion, contraction, building settlement, or seismic movement of the piping system.

2.10.2.1.2. Flexible hose expansion loops shall be manufactured complete with two parallel sections of corrugated metal house, compatible braid, 180 deg return bend, with inlet and outlet connections. Field fabricated loops shall not be acceptable.

2.10.2.1.3. Flexible loops shall be capable of movement in the ±X, ±Y, and ±Z planes.

2.10.2.1.4. Flexible hose expansion loops shall impart no thrust loads to system support, anchors or building structure.

2.10.2.1.5. Materials

- Fittings shall be standard weight, Carbon Steel conforming to ASTM A234 / ASME B16.9
- Corrugated Hose; Stainless Steel, Type 321
- Braid; 304 Stainless Steel.
- End fittings shall carbon steel plate flanges with 150 lb. drilling.
- Flexible hose expansion loops for gas service up to 4" shall be CSA / AGA listed and be in conformance with UL-536.

2.10.2.1.6. Standard of Acceptance: Metraflex, Flexonics

PART 3 - EXECUTION

3.1. **PREPARATION**

3.1.1. Ream pipe ends and remove cutting burrs. Bevel plain end ferrous pipe.

3.1.2. Remove cutting oil, scale and dirt, on inside and outside of piping, before assembly.

3.2. **EQUIPMENT CONNECTIONS**

3.2.1. Provide specified connections, shutoff valves, regulators and unions at each and every appliance and piece of equipment requiring natural gas.

3.2.2. Provide and install union type connections at all equipment to permit removal of service piping.

3.2.3. Gas service connections shall have a diameter at least one pipe size larger than that of the inlet connection to the equipment as provided by the manufacturer and be of adequate size to provide the total input demand of the connected equipment.

3.2.4. Provide listed and labeled appliance connectors complying with ANSI Z21.69 and listed for use with food service equipment having casters, or that is otherwise subject to movement for cleaning, and other large movable equipment. Connectors shall have listed and labeled quick-disconnect devices and shall have retaining cables attached to structures and equipment. Connectors shall not be concealed within or extended through wall, floor or partition and shall be located entirely in the same room as the connected equipment. Provide an accessible shut-off valve not less than the nominal size of the equipment connector, immediately ahead of the connector.

3.2.5. Rigid metallic pipe and fittings shall be used at service connections to all stationary equipment.

3.3. **FLEXIBLE HOSE EXPANSION LOOPS**

3.3.1. Install and guide per manufacturers' installation instructions.

3.3.2. Flexible hose expansion loop return fitting shall be supported to allow movement

3.4. **PIPING INSTALLATION**

3.4.1. Installation shall meet or exceed all applicable provincial and local requirements, referenced standards and conform to codes and ordinances of authorities having jurisdiction.

3.4.2. All installation shall be in accordance with manufacturer's published recommendations.

3.4.3. Provide support for and connections to natural gas service meter in accordance with requirements of the CSA B-149.1 Latest Edition and utility company recommendations, whichever is stricter.

3.4.4. Slope piping down in direction of flow to low points.

3.4.5. Use eccentric reducers at pipe size change installed to provide positive drainage.

3.4.6. Provide clearance for access for maintenance of equipment, valves and fitting

3.4.7. Distribution piping shall be as short and as direct as practicable between the point of delivery and the outlets.

3.4.8. All above ground gas piping shall be electrically continuous and bonded to electrical system ground conductor in accordance with NFPA 70.

3.4.9. Provide and install union type fittings at proper points to permit dismantling or removal of pipe. No unions will be required in welded lines except at equipment connections. Where union type fittings are necessary for piping dismantling purposes, right and left nipples and couplings shall be used. Flanges, ground-joint unions or approved flexible appliance connectors may be used at exposed fixture, appliance or equipment connections.

3.4.10. Provide dielectric isolation device where copper lines connect to ferrous lines or equipment, such as dielectric coupling or dielectric flange fitting.

3.4.11. Valves, regulators, flanges, union type fittings and similar appurtenances shall be accessible for operation and servicing and shall not be located above ceilings, within chases, walls/partitions, spaces utilized as return air plenums or non-accessible locations.

3.4.12. Route piping in orderly manner and maintain gradient. Install piping to conserve building space. Group piping whenever practical at common elevations.

3.4.13. Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment. Refer to TSSA requirements at CSA-B149.1 provisions for distance between expansion joints.

3.4.14. Make service connections at the top of the main, whenever the depth of the main is sufficient to allow top connections. When service connections cannot be made at the top of the main, they shall be made on the side of the main no lower than the horizontal midpoint of the gas main.

3.4.15. Close nipples, bushing and cross type fittings shall not be installed in any gas piping system.

3.4.16. Slope piping and arrange to drain at low points. Install drip/sediment traps at points where condensate and debris may collect. Locate drip/sediment traps where readily accessible for cleaning and emptying. Do not install where condensate would be subject to freezing. Construct drip/sediment traps using tee fitting with capped nipple connected to bottom outlet. Use minimum-length nipple of 3 pipe diameters, but not less than 4 inches long, and same size as connected pipe. Cap shall be screwed pattern, black, standard weight, malleable iron. Install with adequate space for removal of cap.

3.4.17. Install valves for shut off and to isolate equipment, parts of systems, or vertical risers. All valves shall be located such that servicing and operation is possible. All flanged valves shown in horizontal lines with the valve stem shall be positioned so that the valve stem is inclined one bolt hole above the horizontal position. Screw pattern valves placed in horizontal lines shall be installed with their valve stems inclined at an angle of a minimum of 30 degrees above the horizontal position. All valves must be true and straight at the time the system is tested and inspected for final acceptance. Valves shall be installed as nearly as possible to the locations indicated in the Contract Drawings. Any change in valve location must be so indicated on the Record Drawings.

3.4.18. Install line shut-off valve at each branch connection to riser. Branch line shut-off valves shall be automatic type where indicated on Drawings.

3.4.19. Provide adequate clearance for access to and operation of all valves.

3.4.20. Install valves with stems upright or horizontal, not inverted unless required otherwise by the valve manufacturer.

3.4.21. Pipe vents from gas pressure reducing valves and pipe casing sleeves to the exterior of the building and terminated with outlet turned down and capped with corrosion resistant insect screen. Vent terminations shall be at least seven feet above grade or pedestrian traffic and a minimum three (3) feet above or twenty five (25) feet horizontally from all air intakes or building openings.

3.5. **GAS PRESSURE**

3.5.1. Coordinate and review with the local gas supplier the existing meter and main gas regulator. Confirm with the local gas supplier that the current meter and regulator are suitable for the equipment installed under this project, taking into account all other existing gas-fired appliances.

3.5.2. Where applicable to the project, the new gas burners require a min. of 7" w.g. (1.74 kPa) gas pressure when firing at maximum rate. Ensure that the existing gas metering station is adjusted so that all burners receive this pressure when firing at maximum rate and the other gas fired appliances are operational.

3.5.3. Refer to the cash allowance section of these specifications.

3.6. **PIPE HANGERS, SUPPORTS AND ACCESSORIES**

3.6.1. All piping shall be supported as Ontario Gas Code recommendations (CSA B-149.1) or the following (whichever is more restrictive):

3.6.1.1. Above ground horizontal natural gas and encasement piping shall be supported at intervals of no greater than 1,800 mm (6 ft) for ½ inch piping, 2,400 mm (8 ft) for 3/4 inch and 1 inch piping and 3,000 mm (10 ft) for 1¼ inches and larger piping. Vertical piping shall be supported at each floor level and at intervals as specified for horizontal piping. Provide additional supports at fittings as required by TSSA and CSA B-149.1 latest edition.

3.6.2. <u>Indoor Pipe Supports</u>

3.6.2.1. Shop Painting and Plating: Hangers, supports, rods, inserts and accessories used for pipe supports shall be shop coated with red lead or zinc chromate primer paint. Electroplated copper hanger rods, hangers and accessories may be used with copper tubing.

3.6.2.2. Floor, Wall and Ceiling Plates, Supports, Hangers:

3.6.2.2.1. Solid or split unplated cast iron.

3.6.2.2.2. All plates shall be provided with set screws.

3.6.2.2.3. Pipe Hangers: Height adjustable clevis type.

3.6.2.2.4. Adjustable Floor Rests and Base Flanges: Steel.

3.6.2.2.5. Concrete Inserts: "Universal" or continuous slotted type.

3.6.2.2.6. Hanger Rods: Mild, low carbon steel, fully threaded or Threaded at each end with two removable nuts at each end for positioning rod and hanger and locking each in place.

3.6.2.2.7. Riser Clamps: Malleable iron or steel.

3.6.2.2.8. Rollers: Cast iron.

3.6.2.2.9. Self-drilling type expansion shields shall be "Phillips" type, with case hardened steel expander plugs.

3.6.2.3. Hangers and supports utilized with insulated pipe and tubing shall have 180 degree (min.) metal protection shield centered on and welded to the hanger and support. The shield shall be 4 inches in length and be 16 gauge steel. The shield shall be sized for the insulation.

3.6.2.4. Miscellaneous Materials: As specified and/or required for proper installation of hangers, supports and accessories. Provide all necessary auxiliary steel to provide that support.

3.6.2.5. Install cast escutcheon with set screw at each wall, floor and ceiling penetration in exposed finished locations and within cabinets and millwork.

3.6.2.6. Extension bars shall not be used for supporting gas or encasement piping. Gas or encasement piping shall not be used to support any other piping or component.

3.6.3. Outdoor Pipe Supports (Roof)

3.6.3.1. The roof block is an assembled product comprised of two major components including the support shell which is a one piece, UV resistent, thermoplastic injection molded Polypropylene Impact Copolymer and the Type 3, 20 psi extruded polystyrene non-marring base.

3.6.3.2. The support shell (shown left, inverted without base) is designed with an interior web creating eight symmetrical cavities. Design maximizes support strength while substantially reducing the overall weight.

3.6.3.3. Interior cavities allow for expansion and contraction under extreme temperature conditions over its lifetime. The lower portion of the onepiece support shell incorporates a ¾" high wall which reduces UV exposure to the extruded polystyrene base.

3.6.3.4. Min. mounting height above the roof: 300 mm (12"). Use two 12.7 mm electro-zinc all threaded rod risers and 25 mm galvanized slotted channel to achieve required pipe mounting height.

3.6.3.5. Supply metallic galvanized straps to secure pipe to supports and screw on both sides into the support blocks. Use a coarse screw with a large head diameter to maximize retention.

3.6.3.6. Standard of Acceptance: Dura-Block DBE Series, Quick-Block

3.7. **WALLS AND FLOOR PENETRATIONS**

3.7.1. Provide metallic sleeves at all locations where the gas line passes through floor or wall.

3.7.2. Provide fire stopping material in the annular space between the gas line and the sleeve.

3.7.3. Waterproofing: At floor penetrations, completely seal clearances around the pipe and make watertight with sealant.

3.8. **IDENTIFICATION**

3.8.1. All gas piping shall be primed and painted yellow. For outdoors, use outdoor grade paint.

3.8.2. Piping conveying gas at pressures above 6.9 kPa (1 psi) shall be identified as per the TSSA requirements.

3.9. **INSTALLATION OF WELDED PIPING**

3.9.1. Piping and fittings shall be welded and fabricated in accordance with ASME/ANSI the latest editions of Standard B32.1 for all systems. Machine beveling in shop is preferred. Field beveling may be done by flame cutting to recognized standards.

3.9.2. Ensure complete penetration of deposited metal with base metal. Provide filler metal suitable for use with base metal. Maintain inside of fittings free from globules of weld metal. All welded pipe joints shall be made by the fusion welding process, employing a metallic arc or gas welding process. All pipes shall have the ends beveled 37-½ inch degrees and all joints shall be aligned true before welding. Except as specified otherwise, all changes in direction, intersection of lines, reduction in pipe size and the like shall be made with factory-fabricated welding fittings. Mitering of pipe to form elbows, notching of straight runs to form tees, or any similar construction will not be permitted.

3.9.3. Align piping and equipment so that no part is offset more than 1/16 inch. Set all fittings and joints square and true and preserve alignment during welding operation. Use of alignment rods inside pipe is prohibited.

3.9.4. Contractor shall not permit any weld to project within the pipe so as to restrict it. Tack welds, if used, must be of the same material and made by the same procedure as the completed weld. Otherwise, remove tack welded during welding operation.

3.9.5. Do not split, bend, flatten or otherwise damage piping before, during or after installation.

3.9.6. Remove dirt, scale and other foreign matter from the inside of piping, by swabbing or flushing, prior to the connection of other piping sections, fittings, valves or equipment.

3.9.7. In no cases shall Schedule 40 pipe be welded with less than three passes including one stringer/root, one filler and one lacer. Schedule 80 pipe shall be welded with not less than four passes including one stringer/root, two filler and one lacer. In all cases, however, the weld must be filled before the cap weld is added.

3.9.8. Weld Testing:

3.9.8.1. At the Client's request, all welds may be subject to inspection, visual and/or x-ray, for compliance with Specifications. The Client will employ a testing laboratory for the purposes of performing said inspections and/or x-ray testing. Initial visual and

x-ray inspections will be provided by the Client. The Contractor shall be responsible for all labor, material and travel expenses involved in the re-inspection and retesting of any welds found to be unacceptable. In addition, the Contractor shall be responsible for the costs involved in any and all additional testing required or recommended by ASME/ANSI Standards B31.1 and B31.3 due to the discovery of poor, unacceptable or rejected welds.

3.9.8.2. Welds lacking penetration, containing excessive porosity or cracks, or are found to be unacceptable for any reason, must be removed and replaced with an original quality weld as specified herein.

3.10. **TESTING**

3.10.1. All natural gas systems shall be inspected, tested, purged and placed into operation in accordance with NFPA 54 and as required herein.

3.10.2. All necessary apparatus for conducting tests shall be furnished by the Contractor and comply with the requirements of NFPA 54.

3.10.3. All new rough-in distribution piping and affected portions of existing systems connected to, shall be subjected to a pneumatic test pressure utilizing clean, dry air and must be demonstrated to be absolutely tight when subjected to the pressures and time durations listed herein. All equipment and components designed for operating pressures of less than the test pressure shall not be connected to the piping system during test.

3.10.4. Systems on which the normal operating pressure is less than 3.45 kPa (0.5 psi) gauge (psig), the test pressure shall be 34.5 kPa (5.0 psig) and the time interval shall be 30 minutes.

3.10.5. Systems on which the normal operating pressure is between 3.45 kPa (0.5 psig) and 34.5 kPa (5.0 psig), the test pressure shall be 1.5 times the normal operating pressure or 34.5 kPa (5.0 psig), whichever is greater, and the time interval shall be 30 minutes.

3.10.6. Systems on which the normal operating pressure is 34.5 kPa (5.0 psig) or greater, the test pressure shall be 1.5 times the normal operating pressure, and the time interval shall be one (1) hour.

3.10.7. After testing is complete, the entire gas system shall be purged with dry nitrogen to eliminate all air, debris and moisture from the piping before natural gas is introduced into the system.

3.10.8. After successful results of pressure test and purging have been completed, a leakage test shall be performed in accordance with NFPA 54 Appendix D.

3.10.9. Connect, inspect and purge gas utilization equipment, lab hook-ups, outlets, etc., and place into operation only after successful results of pressure test, leakage test and purging have been completed and accepted.

3.10.10. In all instances in which leaks are then found, they shall be eliminated in the manner designated by the Client's duly authorized representative. Testing operations shall be repeated until gas-piping systems are absolutely tight at the pneumatic test pressures indicated above.

3.10.11. The Contractor shall make all arrangements to assure the Consultant and/or Commissioning Agent view the final test and that a certificate is provided from the Inspectors verifying that the installation meets requirements.

3.10.12. Pressure test gas piping sleeve system with clean, dry compressed air at 15 psig by temporarily sealing all openings between gas carrier pipe and sleeve and vent openings. Sleeve systems must be demonstrated to be absolutely tight when subjected to this pressure for a period of four hours.

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1.1.1.2. Exhaust duct for chemical fume hoods, kitchen hood exhaust (grease) and “wet exhaust” ducts.

1.1.2. Section Includes:

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1.1.2.10. Duct sealants.
1.1.2.11. Ductwork sealing, inspection, and leakage testing.
1.1.2.12. Ductwork accessories.

1.1.3. *Section does not include*:

1.1.3.1. *Dust or particle collection ductwork*

1.1.4. Definitions:

1.1.4.1. SMACNA standards as used in this specification means the HVAC Duct Construction Standards, Metal And Flexible.
1.1.4.2. Seal or sealing: use of liquid or mastic sealant, with or without compatible tape overlay, or gasketing of flanged joints, to keep air leakage at duct joints, seams and connections to an acceptable minimum.
1.1.4.3. Duct pressure classification: SMACNA HVAC Duct Construction Standards, Metal and Flexible.
1.1.4.4. Exposed duct: exposed to view in a finished room
1.1.4.5. Outdoor duct: exposed to weather.

1.2. **QUALITY ASSURANCE**

1.2.1. Reference Standards: Products in this section shall be built, tested, and installed in compliance with the following quality assurance standards; latest editions, unless noted otherwise.

1.2.2. Duct system construction and installation: referenced SMACNA standards are the minimum acceptable quality.

1.2.3. Duct sealing, air leakage criteria, and air leakage tests: ducts shall be sealed as per duct sealing requirements of SMACNA HVAC air duct leakage test manual for duct pressure classes shown on the drawings.

1.2.4. Duct accessories exposed to the air stream, such as dampers of all types (except smoke dampers) and access openings, shall be of the same material as the duct or provide at least the same level of corrosion resistance.

1.3. **SUBMITTALS**

1.3.1. Provide the following information and product data:

1.3.1.1. Sealants and gaskets
1.3.1.2. Access doors
1.3.1.3. Hangers and supports
1.3.1.4. Duct fittings
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1.3.2. Applicable Publications

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1.3.2.1.1. A167 99(2009) Standard Specification for Stainless and Heat Resisting Chromium Nickel Steel Plate, Sheet, and Strip

1.3.2.1.2. A653-09 Standard Specification for Steel Sheet, Zinc Coated (Galvanized) or Zinc-Iron Alloy coated (Galvannealed) by the Hot-Dip process

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1.3.2.1.4. B209 07 Standard Specification for Aluminum and Aluminum Alloy Sheet and Plate

1.3.2.1.5. C1071-05e1 Standard Specification for Fibrous Glass Duct Lining Insulation (Thermal and Sound Absorbing Material)

1.3.2.1.6. E84-09a Standard Test Method for Surface Burning Characteristics of Building Materials

1.3.2.2. National Fire Protection Association (NFPA):

1.3.2.2.1. 90A-09 Standard for the Installation of Air Conditioning and Ventilating Systems

1.3.2.2.2. 96-08 Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations

1.3.2.2.3. E. Sheet Metal and Air Conditioning Contractors National Association (SMACNA):

1.3.2.2.4. 2nd Edition – 2005 HVAC Duct Construction Standards, Metal and Flexible

1.3.2.2.5. 1st Edition - 1985 HVAC Air Duct Leakage Test Manual

1.3.2.2.6. 6th Edition – 2003 Fibrous Glass Duct Construction Standards

1.3.2.3. Underwriters Laboratories, Inc. (UL):

1.3.2.3.1. 181 08 Factory Made Air Ducts and Air Connectors

1.3.2.3.2. 555 06 Standard for Fire Dampers

1.3.2.3.3. 555S 06 Standard for Smoke Dampers

1.4. **WARRANTY**

1.4.1. Provide a complete parts and labor warranty for a minimum of one year from the date of Substantial Completion.

PART 2 - PRODUCTS

2.1. **GENERAL USE DUCTWORK**

2.1.1. General: Except for systems specified otherwise, construct ducts, casings, and accessories of galvanized sheet steel of lock-forming quality to ASTM A653, coating G90; or, aluminum sheet, ASTM B209, alloy 1100, 3003 or 5052.

2.1.2. Specified Corrosion Resistant Systems: Stainless steel sheet, ASTM A167, Class 302 or 304, Condition A (annealed) Finish No. 4 for exposed ducts and Finish No. 2B for concealed duct or ducts located in mechanical rooms.

2.1.3. Approved factory made joints may be used.

2.1.4. Provide fittings, branches, inlets and outlets in such a manner that air turbulence is reduced to a minimum.

2.1.5. Rectangular Duct Construction

2.1.5.1. Rectangular duct longitudinal seams shall be Pittsburgh lock 3/8 in. minimum pocket. Crossbreak or bead rectangular ductwork

2.1.5.2. Thickness shall be the more restrictive between the SMACANA Standards and the following:

2.1.5.2.1. Ducts through 12 in. wide: 24 Gage

2.1.5.2.2. Ducts 13 in. through 30 in. wide: 22 Gage.

2.1.5.2.3. Ducts 31 in. through 84 in. wide: 20 Gage.

2.1.5.2.4. Ducts 84 in. and larger: 18 Gage

2.1.5.3. Elbows

2.1.5.3.1. Unless shown otherwise on the drawings, install a 1.5 times width to centerline radius elbow (full radius elbow). Where not possible, use lesser radii configurations, with 'radius-proportional' splitter vanes permanently installed within.

2.1.5.3.2. Only where shown specifically on the drawings, provide square elbows with double thickness vanes.

2.1.5.4. Transitions

2.1.5.4.1. Limit transition angles (for each side) to 15 degrees diverging and 30 degrees converging.

2.1.5.5. Offsets:

2.1.5.5.1. Radiused elbows, as indicated.

2.1.5.6. Take-Off Fittings:

2.1.5.6.1. For take-offs carrying more than 25 percent of duct main, provide an increasing branch elbow with an inside radius equal to branch duct width. Size branch and main at elbow for equal velocity.

2.1.5.6.2. For take-offs carrying 25 percent or less of duct main, provide flanged increased area branch take-off (45 degree entry, "shoe" type) or 45 degree lateral wye takeoffs. Conical fittings shall be used for spiral, round, and oval ductwork.

2.1.5.6.3. For take-offs directly to side outlet for register or grille, provide an increased area tap. For take-offs directly to diffusers see appropriate SMACNA figures.

2.1.5.7. Turning vanes

2.1.5.7.1. Install double wall, airfoil, 2 inch radius vanes in ducts with vane runner length 18" or greater and air velocity less than 2000 fpm. Install double wall, airfoil, 4-1/2 inch radius vanes in ducts with vane runner length 18" or greater and air velocity 2000 fpm or greater.

2.1.5.7.2. If duct size changes in a mitered elbow, use single wall type vanes with a trailing edge extension. If duct size changes in a radius elbow or if short radius elbows must be used, install sheet metal turning vanes in accordance with SMACNA Chart 4-1 and Figure 4-9.

2.1.6. <u>Round Duct Construction</u>

2.1.6.1. All round and oval duct shall be manufactured of spiral lock seams. Ductwork up to 12 in. diameter and 2 in. w.g. can be manufactured with longitudinal lock seams.

2.1.6.2. Minimum galvanized rectangular duct gage shall be the more restrictive between the SMACANA Standards and the following:

2.1.6.2.1. Ducts less than 10" diam: 26 ga spiro duct without ribs

2.1.6.2.2. Ducts 12" to 16" in. diam: 24 Gage

2.1.6.2.3. Ducts 18" through 24" diam: 22 Gage.

2.1.6.2.4. Ducts 26 in. through 30" diam: 20 Gage.

2.1.6.2.5. Ducts 32" diam and larger: 18 Gage

2.1.6.3. Tees shall be conical. Laterals shall be straight. Taps through 10 in. diameter in size shall have a machine drawn entrance and fittings shall have longitudinal seams, continuously welded. Both sides of welds shall be primed with zinc chromate. Tap entrances shall be free of weld build-up.

2.1.6.4. Elbows in diameters 2 in. through 10 in. shall be stamped or pleated. Elbows shall be 5 gore for 90 degrees and 3 gore for 45 degrees. Elbows shall have 1.5 times width to centerline radius (full radius elbow).

2.1.6.5. Flanges, access doors and taps into spiral ducts shall be factory fabricated.

2.1.6.6. Field joints in diameters through 48 in. shall be made with 2 in. long slip-fit, sleeve coupling, or flanges. Duct sealer to be applied on male end connectors before insertion and afterwards to cover the entire joint and sheet metal screws. Sheet metal screws shall be installed at a maximum 300 mm spacing, with a minimum of 3 screws per joint.

2.1.6.7. Ductwork 48 in. diameter and over, and for all sizes where disassembly or removal is required, shall be joined with flanges.

2.2. **SEALING CLASSIFICATION**

2.2.1. Sealant: Elastomeric compound, gun or brush grade, maximum 25 flame spread and 50 smoke developed (dry state) compounded specifically for sealing ductwork as recommended by the manufacturer. Generally provide liquid sealant, with or without compatible tape, for low clearance slip joints and heavy, permanently elastic, mastic type where clearances are larger. Oil base caulking and glazing compounds are not acceptable because they do not retain elasticity and bond.

2.2.2. Tape: Use only tape specifically designated by the sealant manufacturer and apply only over wet sealant. Pressure sensitive tape shall not be used on bare metal or on dry sealant.

2.2.3. Gaskets in Flanged Joints: Soft neoprene.

2.2.4. Sealing classification as per the following table

SEAL CLASS	SEALING REQUIREMENTS	STATIC PRESSURE	ALLOWABLE LEAKAGE RATE
A	All traverse duct joints, all longitudinal duct seams and all duct wall penetrations	-4" to +4" w.g. (1,000 to +1,000 Pa)	1% of total design air flow at 4" w.g. (+1,000 Pa) operating pressure
B	All traverse duct joints, all longitudinal duct seams	-3" to +3" w.g. (-750 to +750 Pa)	1% of total design air flow at 3" w.g. (+750 Pa) operating pressure
C	All traverse duct joints	-2" to +2" w.g. (-500 to +500 Pa)	1.5% of total design air flow at 2" w.g. (+500 Pa) operating pressure
D	Not sealed	-1" to +1" w.g. (-250 to +250 Pa)	5% of total design air flow at 1" w.g. (+250 Pa) operating pressure

Note: Dust collection exhaust ductwork not included.

2.3. **PRESSURE CLASSIFICATIONS**

2.3.1. Ductwork material shall be constructed in accordance with SMACNA ratings for the following pressure classifications. Seal classifications shall be in accordance with the following table:

DUCTWORK	OPERATING PRESSURE	SEAL CLASS	REMARKS
All supply ductwork	-3" to +3" w.g. (-750 to +750 Pa)	B	
All return ductwork	-2" to +2" w.g. (-500 to +500 Pa)	C	
All exhaust ductwork	-2" to +2" w.g. (-500 to +500 Pa)	C	
All other ductwork not listed herein	-1" to +1" w.g. (-250 to +250 Pa)	D	

2.4. **LIQUID TIGHT DUCTWORK**

2.4.1. Applications

2.4.1.1. Exhaust from showers, kitchen dishwashers
2.4.1.2. All outdoor mounted ductwork
2.4.1.3. All swimming pool supply and return/exhaust ductwork

2.4.2. Duct construction:

2.4.2.1. Outdoor ductwork: Min. 18 ga carbon steel continuous external weld for all seams and joints. Provide neoprene gaskets at flanged connections. Where ducts are not

self draining back to the equipment, provide low point drain pocket with copper drain pipe to sanitary sewer. Provide access door in side of duct at drain pockets.

2.4.2.2. Indoor ductwork: Min. thickness of 0.040 in. aluminum alloy 3003H-14 capable of double seaming without fracture, or 316L stainless steel. Ductwork shall be continuously welded and watertight. Pitch duct to low point drains. Pipe drains to floor drains or utility sinks.

2.5. **KITCHEN GREASE EXHAUST DUCTWORK**

2.5.1. Exhaust Ducts: Construct in compliance with NFPA 96, including supports, insulation, clearance from combustible materials, location of access doors and grease collection.

2.5.2. Material: 1.6 mm (16 gage) steel sheet (black iron), ASTM A1011, or 1.3 mm (18 gage) stainless steel. Use stainless steel for exposed duct in occupied areas. See Optional Duct Materials.

2.5.3. Construction: Liquid tight with continuous external weld for all seams and joints. Where ducts are not self draining back to the equipment, provide low point drain pocket with copper drain pipe to sanitary sewer. Provide access doors or panels for duct cleaning inside of horizontal duct at drain pockets, at 6 m (20 feet) intervals, and at each change of direction.

2.5.4. Refer to SMACNA "Guidelines for Welding Sheet Metal" for applicable requirements.

2.5.5. Access doors or panels shall be of the same material and thickness of the duct with gaskets and sealants that are rated 815 degrees C (1500 degrees F) and shall be grease-tight.

2.5.6. Locate access doors at 6 m (20 feet) intervals and at each change in duct direction.

2.5.7. Stainless Steel Ductwork

2.5.7.1. Min 18 ga thickness

2.5.7.2. Concealed stainless steel ductwork shall have an ASTM mill rolled No.1 or No.2 D finish.

2.5.7.3. Exposed stainless steel ductwork shall have an ASTM mill rolled No.2 B finish, or as indicated. Welds shall be ground smooth and final brushed with stainless steel wire brushes. Welds on exposed stainless steel ductwork shall be free of stain, burn-through, or discoloration.

2.5.8. Optional duct construction:

2.5.8.1. Double-wall factory-built grease duct, UL labeled and complying with NFPA 96 may be furnished in lieu of specified materials for kitchen and grill hood exhaust. Installation and accessories shall comply with the manufacturers catalog data.

Outer jacket of exposed ductwork shall be stainless steel. Square and rectangular duct shown in the drawings will have to be converted to equivalent round size.

2.5.8.2. Complete with all pre-manufactured accessories to meet NFPA-96 requirements. Each section shall bear the UL(C) label.

2.5.8.3. Standard of Acceptance: CaptiveAir, Duravent

2.6. **LABORATORY HOOD DUCTWORK**

2.6.1. Laboratory Hood, Exhaust and Associated Ductwork: 1.3 mm (18 gage) all welded Stainless steel.

2.6.2. Stainless Steel Ductwork

2.6.2.1. Minimum stainless steel rectangular duct gauge shall be 18 gauge, for welding.

2.6.2.2. ASTM A167, type 316L.

2.6.2.3. Concealed stainless steel ductwork shall have an ASTM mill rolled No.1 or No.2 D finish.

2.6.2.4. Exposed stainless steel ductwork shall have an ASTM mill rolled No.2 B finish, or as indicated. Welds shall be ground smooth and final brushed with stainless steel wire brushes. Welds on exposed stainless steel ductwork shall be free of stain, burn-through, or discoloration to the satisfaction of the University's Representative/Project Design Engineer.

2.6.2.1. Screws and rivets shall be stainless steel.

2.7. **PLENUMS**

2.7.1. Intake and Exhaust plenums shall be double wall with 2 in. thick duct liner, G-90 galvanized steel solid inner wall (gauge per specified duct minimum standards) and minimum 18 gauge, G-90 galvanized steel outer wall.

2.8. **FLEXIBLE AIR DUCT**

2.8.1. General: Factory fabricated, complying with NFPA 90A for connectors not passing through floors of buildings. Flexible ducts shall not penetrate any fire or smoke barrier which is required to have a fire resistance rating of one hour or more. Flexible duct length shall not exceed 1.5 m (5 feet). Provide insulated acoustical air duct connectors in supply air duct systems and elsewhere as shown.

2.8.2. Flexible ducts shall be listed by Underwriters Laboratories, Inc., complying with UL 181. Ducts larger than 200 mm (8 inches) in diameter shall be Class 1. Ducts 200 mm (8 inches) in diameter and smaller may be Class 1 or Class 2.

2.8.3. Insulated Flexible Air Duct: Factory made including mineral fiber insulation with maximum C factor of 0.25 at 24 degrees C (75 degrees F) mean temperature, encased with a low permeability moisture barrier outer jacket, having a puncture resistance of not less than

50 Beach Units. Acoustic insertion loss shall not be less than 3 dB per 300 mm (foot) of straight duct, at 500 Hz, based on 150 mm (6 inch) duct, of 750 m/min (2500 fpm).

2.8.4. Application Criteria:

2.8.4.1. Temperature range: -18 to 93 degrees C (0 to 200 degrees F) internal.
2.8.4.2. Maximum working velocity: 1200 m/min (4000 feet per minute).
2.8.4.3. Minimum working pressure, inches of water gage: 2500 Pa (10 inches) positive, 500 Pa (2 inches) negative.

2.8.5. Duct Clamps: 100 percent nylon strap, 80 kg (175 pounds) minimum loop tensile strength manufactured for this purpose or stainless steel strap with cadmium plated worm gear tightening device. Apply clamps with sealant and as approved for UL 181, Class 1 installation.

2.9. **DUCT ACCESS DOORS**

2.9.1. Provide access doors, sized and located for maintenance work, upstream, in the following locations:

2.9.1.1. Each in-duct coil (hydronic or DX)
2.9.1.2. Each duct mounted coil and humidifier.
2.9.1.3. Each fire damper (for link service), smoke damper and automatic control damper.
2.9.1.4. Each duct mounted smoke detector.

2.9.2. Openings shall be as large as feasible in small ducts, 300 mm by 300 mm (12 inch by 12 inch) minimum where possible. Access sections in insulated ducts shall be double wall, insulated. Transparent shatterproof covers are preferred for uninsulated ducts.

2.9.3. For rectangular ducts: Refer to SMACNA HVAC Duct Construction Standards (Figure 2 12).

2.9.4. For round and flat oval duct: Refer to SMACNA HVAC duct Construction Standards (Figure 2-11).

2.9.5. Access doors to be designed and constructed for the pressure class of the duct in which the door is to be installed. Doors in exposed areas shall be hinged type with cam sash lock. Hinges shall be aluminum or steel full length continuous piano type. Doors in concealed spaces shall be secured in place with cam sash latches.

2.9.6. For both hinged and non-hinged doors provide sufficient number of camp sash latches to provide air tight seal when door is closed. Do not use hinged doors in concealed spaces if this will restrict access.

2.9.7. Use minimum 1" deep 24 gauge galvanized steel double wall access doors with minimum 24 gauge galvanized steel frames. For non-galvanized ductwork, use minimum 1" deep

double wall access door with frame that shall use materials of construction identical to adjacent ductwork.

2.9.8. Provide double neoprene gasket that shall provide seals from the frame to the door and frame to the duct. When access doors are installed in insulated ductwork or equipment provide insulated doors with insulation equivalent to what is provided for adjacent ductwork or equipment. Access doors constructed with sheet metal screw fasteners will not be accepted.

2.10. **VOLUME CONTROL DAMPERS (MANUAL ADJUSTMENT)**

2.10.1. Single or multi-blade in opposed arrangement, as detailed in SMACNA Standards. Refer to SMACNA Detail Figure 2-12 for Single Blade and Figure 2.13 for Multi-blade Volume Dampers.

2.11. **INSTRUMENT TEST FITTINGS**

2.11.1. Manufactured type with a minimum 50 mm (two inch) length for insulated duct, and a minimum 25 mm (one inch) length for duct not insulated. Test hole shall have a flat gasket for rectangular ducts and a concave gasket for round ducts at the base, and a screw cap to prevent air leakage.

2.11.2. Provide instrument test holes at each duct or casing mounted temperature sensor or transmitter, and at entering and leaving side of each heating coil, cooling coil, and heat recovery unit.

2.12. **DUCTWORK HANGERS AND SUPPORTS**

2.12.1. Generally, hang and support ductwork per the latest edition of SMACNA. Additionally, adhere to the more specific requirements found in this specification section, the Related Sections, and as indicated on the project drawings.

2.12.2. Hanging duct, equipment, or accessories with cables or wires is prohibited.

2.12.3. Provide vibration isolation as specified in Related Section.

2.12.4. Ductwork shall be supported and anchored to structure so that horizontal ducts are without sag or sway, vertical ducts without buckle and all ducts are free from deformation, collapse or vibration

2.12.5. Upper hanger attachments:

2.12.5.1. For concrete: manufactured concrete inserts.

2.12.5.1.1. Standard of Acceptance: Myatt fig 485.

2.12.5.2. For concrete after concrete pour:

2.12.5.2.1. Expanded concrete anchors shall be made of steel.

2.12.5.3. Powder actuated fasteners shall only be utilized for slabs that are thicker than 100 mm (4'') and shall not be utilized in lightweight aggregate concretes.

2.12.5.4. Holes for expanding fasteners shall be drilled either by a carbide bit or by the teeth on the fastener itself. Expansion shield shall be “set'' by driving it into the hole and expanding it with a conical plug.

2.12.5.5. For steel joist: manufactured joist clamp or steel plate washer.

2.12.5.5.1. Standard of Acceptance: Grinnell fig 61 or 86 for joist clamps.

2.12.5.6. For steel beams: manufactured beam clamps:

2.12.5.6.1. Standard of Acceptance: Grinnell fig. 60

2.12.6. Support un-insulated rectangular ducts in sizes up to 600 mm (24 in.) by non-perforated galvanized steel strap or by trapeze hangers. Support insulated rectangular ducts and ducts larger than 36 in. with trapeze hangers. Straps shall be one gauge thicker that the duct material being supported.

2.12.7. Support rectangular ducts in sizes 350 mm (26 in) and larger by galvanized steel angle with black galvanized steel rods to ASHRAE and SMACNA. Space the angle supports in accordance with the following table:

DUCT SIZE	ANGLE SIZE (mm)	ROD SIZE (mm)
Up to 750 mm (30”)	25 x 25 x 3	6
800-1500 mm (32”-60”)	40 x 40 x 3	10
1500-2400 mm (60”-96”)	50 x 50 x 5	10
> 2400 mm (96”)	50 x 50 x 6	10

2.12.8. For round ductwork the duct shall be supported as follows:

2.12.8.1.1. For duct dimensions 900 mm (36'') single strap hangers are acceptable.

2.12.8.1.2. For duct dimensions over 900 mm (36'') use trapeze hangers with rods provided on both sides of the duct.

2.12.8.2. Minimum hanger sizes shall be in accordance with Table 4-2 of SMACNA.

2.12.8.3. Loading on trapeze bars shall be in accordance with Table 4-3 of SMACNA

2.12.9. Install supports on both ends of duct turns, branch fittings and transitions.

2.12.10. Do not hang ductwork from piping, ducts, other trades hangers, existing hangers, or equipment.

2.12.11. Provide supports on each side of any duct mounted equipment or device, including fans, coils, dampers, etc, to permit removal of item without removal of adjacent duct sections.

2.12.12. Provide supplemental steel required to support ductwork in shafts, mechanical rooms or on the floor where structural steel is not properly positioned.

2.12.13. Beam clamps shall be double sided on ducts over 36 in. by 36 in. Use double sided or single sided beam clamps with retaining clips on all other sizes.

2.12.14. Do not modify existing structural steel without approval and a structural engineer's review.

2.12.15. Provide clamping systems that are compatible with the structural steel system of the building.

2.12.16. Use angle iron "V" construction supports or similarly rigid construction for vertical ducting that requires lateral support.

2.12.17. Ductwork mounted on roof or otherwise exposed to elements shall be supported with non-penetrating supports constructed of galvanized steel angles and channels, regardless of duct size. Standard of Acceptance: Portable Pipe Hangers (Canada)

2.12.18. Provide angle sway bracing and diagonal cross bracing to the structure to provide support against maximum lateral loads that may be imposed on the ductwork installed downstream of fan discharges and ductwork exposed to wind loads, and any other locations exposed to lateral loads.

PART 3 - EXECUTION

3.1. **INSTALLATION**

3.1.1. Comply with provisions of Section 23 05 00 Common Work Results for HVAC, particularly regarding coordination with other trades and work in existing buildings.

3.1.2. Comply with the provisions of Section 23 07 11 HVAC System Insulation.

3.1.3. Drawings show the general layout of ductwork and accessories but do not show all required fittings and offsets that may be necessary to connect ducts to equipment, boxes, diffusers, grilles, etc., and to coordinate with other trades. Fabricate ductwork based on field measurements. Provide all necessary fittings and offsets at no additional cost to the government. Coordinate with other trades for space available and relative location of HVAC equipment and accessories on ceiling grid. Duct sizes on the drawings are inside dimensions which shall be altered by Contractor to other dimensions with the same air handling characteristics where necessary to avoid interferences and clearance difficulties.

3.1.4. Ductwork shall be installed to true alignment, parallel or perpendicular to adjacent building walls, floors and ceilings, to present a neat and workmanlike appearance.

3.1.5. Provide duct transitions, offsets and connections to dampers, coils, and other equipment in accordance with SMACNA Standards, Section II. Provide streamliner, when an

obstruction cannot be avoided and must be taken in by a duct. Repair galvanized areas with galvanizing repair compound.

3.1.6. Provide bolted construction and tie rod reinforcement in accordance with SMACNA Standards.

3.1.7. Construct casings, eliminators, and pipe penetrations in accordance with SMACNA Standards, Chapter 6. Design casing access doors to swing against air pressure so that pressure helps to maintain a tight seal.

3.1.8. Install duct hangers and supports in accordance with SMACNA Standards, Chapter 4.

3.1.9. For ductwork mounted outdoors, install duct with slight lateral pitch to prevent water ponding on top of duct.

3.1.10. Install special equipment items in ductwork systems including, but not limited to: control dampers, thermometers, airflow measuring devices and other related items, according to manufacturer's recommendations.

3.1.11. Seal openings around duct penetrations of floors and fire rated partitions with fire stop material as required by NFPA 90A.

3.1.12. Flexible duct installation: Refer to SMACNA Standards, Chapter 3. Ducts shall be continuous, single pieces not over 1.5 m (5 feet) long (NFPA 90A), as straight and short as feasible, adequately supported. Centerline radius of bends shall be not less than two duct diameters. Make connections with clamps as recommended by SMACNA. Clamp per SMACNA with one clamp on the core duct and one on the insulation jacket. Flexible ducts shall not penetrate floors, or any chase or partition designated as a fire or smoke barrier, including corridor partitions fire rated one hour or two hour. Support ducts SMACNA Standards.

3.1.13. Where diffusers, registers and grilles cannot be installed to avoid seeing inside the duct, paint the inside of the duct with flat black paint to reduce visibility.

3.1.14. Protection and Cleaning:

3.1.14.1. Adequately protect equipment and materials against physical damage. Place equipment in first class operating condition, or return to source of supply for repair or replacement, as determined by the Consultant. Protect equipment and ducts during construction against entry of foreign matter to the inside and clean both inside and outside before operation and painting. When new ducts are connected to existing ductwork, clean both new and existing ductwork by mopping and vacuum cleaning inside and outside before operation.

3.2. **DUCT LEAKAGE TESTS AND REPAIR**

3.2.1. Ductwork leakage testing shall be performed by the Testing and Balancing Contractor. For maximum leakage rates, refer to pressure classifications and sealing classifications included in part 2 of these specifications

3.2.2. Ductwork leakage testing shall be performed for the entire air distribution system (including all supply, return, exhaust and relief ductwork), section by section, including fans, coils and filter sections.

3.2.3. All ductwork shall be leak tested first before enclosed in a shaft or covered in other inaccessible areas.

3.2.4. If any portion of the duct system tested fails to meet the permissible leakage level, the Contractor shall rectify sealing of ductwork to bring it into compliance and shall retest it until acceptable leakage is demonstrated to the Resident Engineer.

3.2.5. All tests and necessary repairs shall be completed prior to insulation or concealment of ductwork.

3.2.6. Duct Leakage Testing Procedures:

3.2.6.1. Prior to fabrication and installation, develop and submit for approval a ductwork testing plan, indicating locations of temporary caps, surface area of ductwork test sections, test pressure, leakage class and allowable leakage in cubic feet per minute.

3.2.6.2. Notify the Client's Representative at least 2 days prior to each test.

3.2.6.3. Provide all blank-off plates, flanges, and sealing required to isolate each section of duct to be tested.

3.2.6.4. Provide necessary testing apparatus.

3.2.6.5. For all ducts, pressurize ductwork to the specified pressure class and inspect ductwork for visual and audible leaks, and leaks perceptible to a hand 2 in. from duct. Reseal all perceptible leaks until acceptable to Client's Representative.

3.2.6.6. After completing visual and audible inspection, conduct measured ductwork leakage tests at the specified pressure class for the duct. Reseal and retest as required until successfully achieving the specified leakage class.

3.2.6.7. Submit leakage test report for approval, using SMACNA or other approved form.

3.2.6.8. Make sure all openings used for testing flow and temperatures by TAB Contractor are sealed properly.

3.3. **DUCT PAINTING**

3.3.1. Where the interior of duct is visible through grilles, registers, diffusers or other air diffusion devices, paint the interior flat black. Coordinate work with Architectural Trade.

3.3.2. For plenum returns, where equipment and structure above ceiling is visible through return air grilles, provide black sheet metal baffle with turned edges suspended from building construction. Size and position the baffle to prevent restriction of air flow. Where space above ceiling precludes use of a baffle, paint visible building surfaces flat black.

3.4. **DUCTWORK EXPOSED TO WIND VELOCITY**

3.4.1. Provide additional support and bracing to all exposed ductwork installed on the roof or outside the building to withstand wind velocity of145 km/h (90 mph).

3.4.2. All bracing to be to be stamped and sealed by a licensed Structural Professional Engineer and submitted for review. All engineering services required for additional strapping to be provided by the roof duct support manufacturer and paid for by the Contractor.

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1.2. **RELATED WORK**

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1.2.2. Section: 23 05 93 Testing, Adjusting and Balancing For HVAC.

1.3. **REFERENCE STANDARDS**

1.3.1. The latest published edition of a reference shall be applicable to this Project unless identified by a specific edition date.

1.3.2. All reference amendments adopted prior to the effective date of this Contract shall be applicable to this Project.

1.3.3. All materials, installation and workmanship shall comply with the applicable requirements and standards addressed within the following references:

1.3.3.1. AMCA 500 Test Method for Louvers, Dampers and Shutters.
1.3.3.2. ANSI/NFPA 90A Installation of Air Conditioning and Ventilating Systems.
1.3.3.3. ARI 890 – Rating of Air Diffusers and Air Diffuser Assemblies.
1.3.3.4. ASHRAE 70 Method of Testing for Rating the Air Flow Performance of Outlets and Inlets.
1.3.3.5. SMACNA 1035 - HVAC Duct Construction Standards - Metal and Flexible.

1.4. **QUALITY ASSURANCE**

1.4.1. Test and rate performance of air outlets and inlets in accordance with ASHRAE 70.

1.4.2. Test and rate performance of louvers in accordance with AMCA 500.

1.4.3. Fire Safety Code: Comply with NFPA 90A.

1.5. **SUBMITTALS**

1.5.1. All air distribution equipment to be the product of the same manufacturer.

1.5.2. Submit in accordance with Section: 01 33 23 Shop Drawings, Product Data, and Samples the following:

1.5.2.1. Manufacturer's name and model number
1.5.2.2. Identification as referenced in the documents

1.5.2.3. Capacities/ratings
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PART 2 - PRODUCTS

2.1. **ADJUSTABLE SQUARE CONE DIFFUSERS - FIRE RATED**

2.1.1. General

2.1.1.1. The square cone diffuser shall be supplied to deliver a 360 degree radial, horizontal airflow pattern. The cones and backpan shall be one-piece die-formed with smooth, aerodynamically designed surfaces and no corner joints. This contoured design shall protect the ceiling and help to prevent smudging and streaking.

2.1.2. Construction:

2.1.2.1. Diffusers shall be steel construction, and shall consist of a seamless, one-piece, precision formed backpan that incorporates a round inlet collar of sufficient length for connecting rigid or flexible duct and an outer frame which is recessed from the ceiling plane to allow for field adjustment of the airflow discharge from fully horizontal to fully vertical.

2.1.2.2. An inner cone assembly shall consist of [3 cones] or [optional 4 cones] which drop below the ceiling plane to assure optimal VAV air diffusion performance. The inner cone assembly shall be completely removable from the diffuser face to allow for full access to any dampers or other ductwork components located near the diffuser neck.

2.1.2.3. Non-protrusive airflow directional tabs shall be provided on the back of the inner cones which may be positioned for either horizontal or vertical discharge.

2.1.2.4. The diffuser ceiling module and neck size shall be as indicated on the drawings and equipment schedules.

2.1.3. Paint Specification:

2.1.3.1. Paint finish shall be as per the architectural finishing schedule. All components shall have a baked-on powder coat finish.

2.1.3.2. The paint finish must demonstrate no degradation when tested in accordance with ASTM D1308 (covered and spot immersion) and ASTM D4752 (MEK double rub) paint durability tests.

2.1.3.3. The paint film thickness shall be a minimum of 2.0 mils.

2.1.3.4. The finish shall have a hardness of 2H.

2.1.3.5. The finish shall withstand a minimum salt spray exposure of 500 hours with no measurable creep in accordance with ASTM D1654, and 1000 hours of exposure with no rusting or blistering as per ASTM D610 and ASTM D714.

2.1.3.6. The finish shall have an impact resistance of 80 inch-pounds.

2.1.3.7. All components shall have a custom finish in a color to match a customer supplied sample.

2.1.4. Damper:

2.1.4.1. The diffuser shall be supplied with a galvanized steel, non-adjustable, butterfly-type ceiling radiation damper.

2.1.5. Thermal Blanket:

2.1.5.1. The diffuser shall be externally wrapped with a non-asbestos thermal blanket.

2.1.6. Fusible Link:

2.1.6.1. The diffuser shall be supplied with a fusible link rated for 165 degrees Fahrenheit.

2.1.7. Mounting Frame:

2.1.7.1. The diffuser mounting frame shall be suitable for lay-in or surface mount applications with a 15/16 inch fire-rated T-bar frame style.

2.1.8. Volume Control:

2.1.8.1. The diffuser shall be supplied with a steel volume control damper that is room side adjustable with an allen key for balancing.

2.1.9. Standard of Acceptance: E.H.Price model SCDA-FR, Titus, Ruskin

2.2. **ROUND CONE DIFFUSER - ADJUSTABLE DISCHARGE PATTERN**

2.2.1. Round ceiling diffusers aluminum with steel screws, adjustable. The diffusers shall have four cones and round neck inlets of the sizes and mounting types shown on the plans and outlet schedule.

2.2.2. Round diffusers shall be constructed of 0.051 aluminum. The airflow discharge pattern shall be field adjustable from horizontal to vertical by extending or retracting the inner three cones.

2.2.3. These three cones shall be constructed as a single inner assembly and must be easily removable using a spring lock mechanism.

2.2.4. Vertical to horizontal discharge pattern must be achieved by one of three adjustment methods as follows:

2.2.4.1. Type 1. The inner cone assembly can be removed and repositioned by means of adjusting screws.

2.2.4.2. Type 2. The inner cone assembly can be adjusted by sliding the cones up or down.

2.2.4.3. Type 3. The center cone can be rotated clockwise or counterclockwise to move the cones up or down.

2.2.5. Volume Control

2.2.5.1. Round damper shall be constructed of heavy gauge steel. Damper must be operable from the face of the diffuser. A retainer cable shall be provided to allow the inner core assembly to hang during maintenance of diffusers with a neck size of 12 inches or greater.

2.2.6. Finish

2.2.6.1. The finish shall be as per the architectural finishing schedule.

2.2.6.2. The finish shall be an anodic acrylic paint, baked at 315°F for 30 minutes. The pencil hardness must be HB to H.

2.2.6.3. The paint must pass a 100-hour ASTM B117 Corrosive Environments Salt Spray Test without creepage, blistering or deterioration of film. The paint must pass a 250-hour ASTM D870 Water Immersion Test. The paint must also pass the ASTM D2794 Reverse Impact Cracking Test with a 50-inch pound force applied.

2.2.7. Standard of Acceptance: E.h.Price model ARCD, Titus, Ruskin

PART 3 - EXECUTION

3.1. **GENERAL**

3.1.1. All installation shall be in accordance with manufacturer's published recommendations.

3.1.2. Check location of air outlets and inlets and make necessary adjustments in position to conform to architectural features, reflected ceiling plans, symmetry, and lighting arrangement. Coordinate location of air distribution equipment with lighting fixtures, fire alarm and PA devices.

3.1.3. Install air outlets and inlets to ductwork with airtight connection.

3.1.4. Provide balancing dampers on duct take off to diffusers, grilles and registers, regardless of whether dampers are specified as part of the diffuser, grille, or register assembly.

3.1.5. Provide all specialties and frames for air distribution devices as required for proper installation in ceiling type as indicated on Architectural Drawings. Provide all cutting and patching of T-bars, gypsum board, and other ceiling systems as required for installation of air devices.

3.1.6. Where diffusers, registers and grilles cannot be installed to avoid seeing inside duct, paint inside of duct with flat black paint to reduce visibility.

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PART 1 - GENERAL

1.1. **DESCRIPTION**

1.1.1. Roof top air handling units including integral components specified herein.

1.1.2. Definitions: Roof Top Air Handling Unit: A factory fabricated assembly consisting of fan, coils, filters, and other necessary equipment to perform one or more of the following functions of circulating, cleaning, heating, cooling, humidifying, dehumidifying, and mixing of air. Design capacities of units shall be as scheduled on the drawings.

1.2. **RELATED WORK**

1.2.1. Section 23 05 00 COMMON WORK RESULTS FOR HVAC

1.2.2. Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC

1.2.3. Section 23 05 93 TAB

1.3. **QUALITY ASSURANCE**

1.3.1. Air Handling Units Certification

1.3.1.1. Air Handling Units with Housed Centrifugal Fans: The air handling units shall be certified in accordance with AHRI 430 and tested/rated in accordance with AHRI 260.

1.3.1.2. Air Handling Units with Plenum Fans:

1.3.1.2.1. Air Handling Units with a single Plenum Fan shall be certified in accordance with AHRI 430 and tested/rated in accordance with AHRI 260.

1.3.1.2.2. Air handling Units with Multiple Fans in an Array shall be tested and rated in accordance with AHRI 430 and AHRI 260.

1.3.1.3. Heating, Cooling, and Air Handling Capacity and Performance Standards: AHRI 430, AHRI 410, ASHRAE 51, and AMCA 210.

1.3.2. Performance Criteria:

1.3.2.1. The fan BHP shall include all system effects for all fans and v-belt drive losses for housed centrifugal fans.

1.3.2.2. The fan motor shall be selected within the rated nameplate capacity, without relying upon NEMA Standard Service Factor.

1.3.2.3. Select the fan operating point as follows:

1.3.2.3.1. Forward Curve and Axial Flow Fans: Right hand side of peak pressure point.

1.3.2.3.2. Air Foil, Backward Inclined, or Tubular Fans Including Plenum Fans: At or near the peak static efficiency but at an appropriate distance from the stall line.

1.3.3. Operating Limits: AMCA 99 and Manufacturer's Recommendations.

1.3.4. Units shall be factory-fabricated, assembled, and tested by a manufacturer, in business of manufacturing similar air-handling units for at least five (5) years.

1.4. **SUBMITTALS**

1.4.1. The contractor shall furnish a complete submission for all roof top units covered in the project. The submission shall include all information listed below. Partial and incomplete submissions shall be rejected without reviews.

1.4.2. Manufacturer's Literature and Data:

1.4.2.1. Submittals shall include fans, drives, motors, coils, mixing box with outside/return air dampers, filter housings and all other related accessories. The contractor shall provide custom drawings showing total air handling unit assembly including dimensions, operating weight, access sections, flexible connections, door swings, controls penetrations, electrical disconnect, lights, duplex receptacles, switches, wiring, utility connection points, unit support system, vibration isolators, drain pan, pressure drops through each component (filter, coil etc) and rigging points.

1.4.2.2. Submittal drawings of section or component only, will not be acceptable. Contractor shall also submit performance data including performance test results, charts, curves or certified computer selection data; data sheets; fabrication and insulation details; if the unit cannot be shipped in one piece, the contractor shall indicate the number of pieces that each unit will have to be broken into to meet shipping and job site rigging requirements. This data shall be submitted in hard copies and in electronic version compatible to AutoCAD version used by the VA at the time of submission.

1.4.2.3. Submit sound power levels in each octave band for fan and at entrance and discharge of equipment at scheduled conditions.

1.4.2.4. Provide fan curves showing Liters/Second (cubic feet per minute), static pressure, efficiency, and horsepower for design point of operation and at maximum design Liters/Second (cubic feet per minute) and 110 percent of design static pressure.

1.4.2.5. Submit total fan static pressure, external static pressure, for RTU including total, inlet and discharge pressures, and itemized specified internal losses and unspecified internal losses. Refer to air handling unit schedule on drawings.

1.4.3. Maintenance and operating manuals. Include instructions for lubrication, filter replacement, motor and drive replacement, spare part lists, and wiring diagrams.

1.4.4. Submit shipping information that clearly indicates how the units will be shipped in compliance with the descriptions below.

1.4.4.1. Units shall be shipped in one (1) piece where possible and in shrink wrapping to protect the unit from dirt, moisture and/or road salt.

1.4.4.2. If not shipped in one (1) piece, provide manufacturer approved shipping splits where required for installation or to meet shipping and/or job site rigging requirements in modular sections. Indicate clearly that the shipping splits shown in the submittals have been verified to accommodate the construction constraints for rigging as required to complete installation and removal of any section for replacement through available access without adversely affecting other sections.

1.4.4.3. If shipping splits are provided, each component shall be individually shrink wrapped to protect the unit and all necessary hardware (e.g. bolts, gaskets etc.) will be included to assemble unit on site.

1.4.4.4. Lifting lugs will be provided to facilitate rigging on shipping splits and joining of segments. If the unit cannot be shipped in one piece, the contractor shall indicate the number of pieces that each unit will have to be broken into to meet shipping and job site rigging requirements.

1.5. **APPLICABLE PUBLICATIONS**

1.5.1. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.

1.5.2. Air Conditioning, Heating, and Refrigeration Institute (AHRI):

1.5.2.1. 260-01 Sound Rating of Ducted Air Moving and Conditioning Equipment

1.5.2.2. 410 01 Standard for Forced-Circulation Air-Heating and Air-Cooling Coils

1.5.2.3. 430 09 Standard for Central Station Air Handling Units

1.5.3. Air Moving and Conditioning Association (AMCA):

1.5.3.1. 210 07 Laboratory Methods of Testing Fans for Rating

1.5.4. American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE):

1.5.4.1. 51 2007 Laboratory Methods of Testing Fans for Rating

1.5.4.2. National Fire Protection Association (NFPA):

1.5.5. NFPA 90A Standard for Installation of Air Conditioning and Ventilating Systems, 2009

1.6. **STANDARD OF ACCEPTANCE**

1.6.1. AAON (Basis of Design)

1.6.2. Trane

1.6.3. Daikin

1.6.4. EngineeredAir

1.7. **BASIS OF DESIGN**

1.7.1. Basis of Design equipment is custom manufactured to match accurately the existing support structures and location of roof mounted ductwork, access points and power supplies.

1.7.2. Any other manufactured item submitted as an equal shall have to match exactly the footprint, capacity, weight and all other characteristics of the Basis of Design Equipment. Any discrepancy noted at shop drawings submission will result in immediate rejection.

1.8. **WARRANTY**

1.8.1. The warranty period shall commence at the date of initial start up and shall continue for a period of two (2) year not to exceed eighteen (18) months from shipment. Manufacturer's warranty shall include parts only.

PART 2 - PRODUCTS

2.1. **GENERAL**

2.1.1. Units shall consist of filter section, supply air fan section, exhaust fans (as applicable), high efficiency indirect gas heating section, DX cooling section, fan sections, motorized dampers, economizer section c/w motorized damper relief, control panel, and all other components required for complete installation.

2.2. **CASING**

2.2.1. All cabinet walls, access doors, and roof shall be fabricated of double wall, impact resistant, rigid polyurethane foam panels.

2.2.2. Unit insulation shall have a minimum thermal resistance R-value of 13. Foam insulation shall have a minimum density of 2 pounds/cubic foot and shall be tested in accordance with ASTM D1929-11 for a minimum flash ignition temperature of 610°F.

2.2.3. Unit construction shall be double wall with G90 galvanized steel on both sides and a thermal break. Double wall construction with a thermal break prevents moisture

accumulation on the insulation, provides a cleanable interior, reduces heat transfer through the panel, and prevents exterior condensation on the panel.

2.2.4. Unit shall be designed to reduce air leakage and infiltration through the cabinet. Cabinet leakage shall not exceed 1% of total airflow when tested at 3 times the minimum external static pressure provided in AHRI Standard 340/360. Panel deflection shall not exceed L/240 ratio at 125% of design static pressure, at a maximum 8 inches of positive or negative static pressure, to reduce air leakage. Deflection shall be measured at the midpoint of the panel height and width. Continuous sealing shall be included between panels and between access doors and openings to reduce air leakage. Piping and electrical conduit through cabinet panels shall include sealing to reduce air leakage.

2.2.5. Roof of the air tunnel shall be sloped to provide complete drainage. Cabinet shall have rain break overhangs above access doors.

2.2.6. Access to filters, dampers, cooling coils, heaters, energy recovery wheels, and electrical and controls components shall be through hinged access doors with quarter turn, zinc cast, lockable handles. Full length stainless steel piano hinges shall be included on the doors.

2.2.7. Exterior paint finish shall be capable of withstanding at least 2,500 hours, with no visible corrosive effects, when tested in a salt spray and fog atmosphere in accordance with ASTM B 117-95 test procedure.

2.2.8. Units with cooling coils shall include double sloped 304 stainless steel drain pans.

2.2.9. Unit shall be provided with base discharge and return air openings. All openings through the base pan of the unit shall have upturned flanges of at least 1/2 inch in height around the opening.

2.2.10. Unit shall include lifting lugs on the top of the unit.

2.2.11. Unit base pan shall be provided with 1/2 inch thick foam insulation.

2.2.12. Unit shall include factory installed, painted galvanized steel condenser coil guards on the face of the condenser coil.

2.2.13. The following components shall be provided with a 22 gauge (.85mm) solid galvanized metal or 24 gauge (.70mm) perforated (40% free area) galvanized metal liner over insulated areas:

2.2.13.1.	Fan Sections:	solid liner
2.2.13.2.	Filter Sections:	perforated liner
2.2.13.3.	All Access Sections:	solid liner
2.2.13.4.	All hydronic/DX coils:	solid liner

2.2.13.5. Gas heat exchanger: solid liner

2.3. **ACCESS DOORS**

2.3.1. Units shall be provided with access doors to the following components:

2.3.1.1. Fan and motors and control panels
2.3.1.2. Filters
2.3.1.3. Dampers and Operators
2.3.1.4. Access Plenums

2.3.2. Access Doors shall be large enough for easy access. Removal of screwed wall panels will not be acceptable. All doors shall have a standard (re-rod) hold open latch arrangement, which will provide stiffened support for the door during wind days.

2.3.3. Provide hinged access doors, fully lined, quarter-turn handles, operable from both sides for all units at and over 48 in. (1220mm) high.

2.3.4. Whenever possible, hinged access doors to areas of negative pressure shall open out, and to areas of positive pressure shall open in. Where space constrictions require the use of outward opening doors to an area of positive pressure, a clear warning label must be affixed.

2.4. **INSULATION**

2.4.1. All units shall be internally insulated with:

2.4.1.1. 2” (50mm) thick 3 lb./cu.ft. (48kg./cu.m.) density, neoprene coated fibre glass thermal insulation. Minimum value of R-13.
2.4.1.2. Insulation shall be secured to metal panels with a fire retardant adhesive and welded steel pins at 16” (400MM) o/c. All longitudinal insulation joints and butt ends shall be covered by a sheet metal break to prevent erosion of exposed edges. Drain pans and all floor areas shall be insulated on the underside.

2.5. **FILTERS**

2.5.1. Unit shall include 4 inch thick, pleated panel filters with an ASHRAEMERV rating of 13, upstream of the cooling coil. Unit shall also include 2 inch thick, pleated panel pre filters with an ASHRAE MERV rating of 8, upstream of the 4 inch standard filters.

2.5.2. Unit shall include a clogged filter switch.

2.5.3. Unit shall include a Magnehelic gauge mounted in the controls compartment.

2.6. **FAN SECTIONS**

2.6.1. Centrifugal fans shall be rated in accordance with AMCA Standard Test Code, Bulletin 210. Fan manufacturer shall be a member of AMCA. All fans and fan assemblies shall be dynamically balanced during factory test run. Fan shafts shall be selected for stable operation at least 20% below the first critical RPM. Fan shafts shall be provided with a rust inhibiting coating.

2.6.2. Supply fan motor shall be direct drive type with factory installed variable frequency drive. All motors shall be thermally protected.

2.6.3. Motor, fan bearings and drive assembly shall be located inside the fan plenum to minimize bearing wear and to allow for internal vibration isolation of the fan-motor assembly, where required.

2.6.4. All fans shall be mounted on rubber vibration isolators, to reduce the transmission of noise.

2.6.5. Fan motor on supply motor shall be rated for fan duty, open drip proof, super high efficient (equal to CSA 390 M 1985) T-frame, and 208 Volt, 3 Phase, 60 Cycle.

2.7. **DAMPERS**

2.7.1. The unit shall have a factory installed and integrated 100% outdoor air hood with damper controlled by a direct coupled actuator and 2" permanent and washable aluminum mesh filters accessible through a hinged access door.

2.7.2. Intake damper damper insulated, extruded aluminium, opposed blade type respectively, to be Tamco 9000 series. Damper actuators to be Belimo model AF24(s) or AF120(s) c/w manual over ride option.

2.8. **INDIRECT GAS FIRED AUXILIARY HEATING SECTION**

2.8.1. Heating units shall have an indirect propane gas heating section that is C-ETL, approved for both sea level and high-altitude areas. The entire assembly shall be approved and labelled by a nationally recognized certification agency.

2.8.2. Operating natural propane pressure at unit(s) manifold shall be minimum 7" (1750 Pa) w.c.

2.8.3. Propane fired units shall be approved for operation in -40F (-40C) locations.

2.8.4. Heat exchanger shall be a primary drum and multi-tube secondary assembly constructed of titanium stainless steel with multi-plane metal turbulators, and shall be of a floating stress relieved design. Heat exchanger shall be provided with condensate drain connection. The heat exchanger casing shall have 1" (25mm) of insulation between the

outer cabinet and inner liner. Blower assemblies close coupled to duct furnace type heat exchangers are not acceptable.

2.8.5. Units with high efficiency heat exchangers shall be tested and certified to ANSI standards to provide a minimum of 80% efficiency throughout the entire operating range. The manufacturer shall be routinely engaged in the manufacture of this type of high efficiency equipment.

2.8.6. The burner assembly shall be a blow through positive pressure type with an intermittent pilot ignition system to provide a high seasonal efficiency. Flame surveillance shall be with a solid state programmed flame relay c/w flame rod. The burner and gas train shall be in a cabinet enclosure. Insulation in the burner section shall be covered by a heat reflective galvanized steel liner. Atmospheric burners, or burners requiring power assisted venting are not acceptable.

2.8.7. Unit discharge air control shall include 10:1 turndown (HT burner). The high turndown burner minimum input shall be capable of controlling at 6.7% of its rated input without on-off cycling.

2.8.8. Installation and venting provisions must be in accordance with local gas codes. Venting shall follow AL29-4C special venting for high 90% efficient heat exchanger

2.9. **DX COIL**

2.9.1. Internally finned, inch copper tubes mechanically bonded to a configured aluminum plate fin shall be standard.

2.9.2. Coils shall be leak tested at the factory to ensure the pressure integrity. The evaporator coil shall be leak tested to 500 psig and pressure tested to 500 psig.

2.9.3. Coils shall be designed for use with R-454B refrigerant and constructed of copper tubes with aluminum fins mechanically bonded to the tubes and galvanized steel end casings. Fin design shall be sine wave rippled.

2.9.4. Coils shall be hydrogen or helium leak tested.

2.9.5. Coils shall be furnished with factory installed expansion valves.

2.9.6. A stainless steel double-sloped condensate drain pan with provision for through the unit wall condensate drain is standard.

2.9.7. Unit shall be configured as an air-source heat pump. Each refrigeration circuit shall be equipped with a factory installed liquid line filter drier with check valve, reversing valve, accumulator, and expansion valves on both the indoor and outdoor coils. Reversing valve shall energize during the heat pump cooling mode of operation.

2.9.8. Each refrigeration circuit shall be equipped with a liquid line sight glass.

2.10. **COMPRESSORS**

2.10.1. Unit shall have a direct-drive hermetic, digital scroll type compressors with centrifugal type oil pumps. Motor shall be suction gas-cooled and shall have a voltage utilization range of plus or minus 10 percent of unit nameplate voltage.

2.10.2. Internal overloads shall be provided with the scroll compressors. Compressor shall be able to fully modulate from 20% to 100%.

2.10.3. Crankcase heaters shall be included as standard.

2.11. **OUTDOOR COIL**

2.11.1. Fin & Tube Coil

2.11.1.1. Internally finned, copper tubes mechanically bonded to a configured aluminum plate fin shall be standard.

2.11.1.2. Coils shall be leak tested at the factory to ensure the pressure integrity. The evaporator coil shall be leak tested to 500 psig and pressure tested to 500 psig.

2.11.1.3. The condenser coil shall have a fin design with slight gaps for ease of cleaning.

2.11.2. Outdoor fans

2.11.2.1. Shall be direct drive vertical discharge design with low-noise corrosion resistant glass reinforced polypropylene propellors, powder coated wire discharge guards with electro-plated motor mounting brackets.

2.11.2.2. Fans shall be statically and dynamically balanced.

2.12. **HEAT WHEEL**

2.12.1. Unit shall contain a factory mounted and tested energy recovery wheel. The energy recovery wheel shall be mounted in a rigid frame containing the wheel drive motor, drive belt, wheel seals and bearings. Frame shall slide out for service and removal from the cabinet.

2.12.2. The energy recovery component shall incorporate a rotary wheel in an insulated cassette frame complete with seals, drive motor and drive belt.

2.12.3. Units shall contain two 64 in. energy recovery wheels with a 2 in. minimum media thickness oriented in a "V" formation in the factory assembled cabinet.

2.12.4. The energy recovery cassette shall be an Underwriters Laboratories Recognized Component for electrical and fire safety. The wheel drive motor shall be an Underwriters Laboratory Recognized Component and shall be mounted in the cassette frame and

supplied with a service connector or junction box. Thermal performance shall be certified by the manufacturer in accordance with ASHRAE Standard 84, Method of Testing Air-to-Air Heat Exchangers and AHRI Standard 1060, Rating Air-to-Air Energy Recovery Ventilation Equipment. Cassettes shall be listed in the AHRI Certified Products.

2.12.5. Energy recovery wheel cassette shall carry a 5 year non-prorated warranty, from the date of original equipment shipment from the factory. The first 12 months from the date of equipment startup, or 18 months from the date of original equipment shipment from the factory, whichever is less, shall be covered under the standard limited parts warranty. The remaining period of the warranty shall be covered by Airxchange. The 5 year warranty applies to all parts and components of the cassette, with the exception of the motor, which shall carry an 18 month warranty. Warranty shall cover material and workmanship that prove defective, within the specified warranty period, provided the Airxchange written instructions for Installation, Operation, and Maintenance have been followed. Warranty excludes parts associated with routine maintenance, such as belts. Refer to the Airxchange Energy Recovery Cassette Limited Warranty Certificate.

2.12.6. Unit shall include 2 inch thick, pleated panel outside air filters with an ASHRAE MERV rating of 8, upstream of the wheels.

2.12.7. Hinged service access doors shall allow access to the wheel.

2.12.7.1. Polymer Energy Recovery Wheels

2.12.7.1.1. Shall be provided with removable energy transfer matrix. Wheel frame construction shall be a welded hub, spoke and rim assembly of stainless, plated and/or coated steel and shall be self-supporting without matrix segments in place. Segments shall be removable without the use of tools to facilitate maintenance and cleaning. Wheel bearings shall be selected to provide an L-10 life in excess of 400,000 hours. Rim shall be continuous rolled stainless steel and the wheel shall be connected to the shaft by means of taper locks.

2.12.7.1.2. All diameter and perimeter seals shall be provided as part of the cassette assembly and shall be factory set. Drive belts of stretch urethane shall be provided for wheel rim drive.

2.12.7.1.3. Polymer Energy recovery wheel cassette shall carry a 5 year non-prorated warranty, from the date of original equipment shipment from the factory. The first 12 months from the date of equipment startup, or 18 months from the date of original equipment shipment from the factory, whichever is less, shall be covered under the standard limited parts warranty. The remaining period of the warranty shall be covered by Airxchange. The 5-year warranty applies to all parts and components of the cassette, with the exception of the motor, which shall carry an 18 month warranty. Warranty shall cover material

and workmanship that prove defective, within the specified warranty period, provided the Airxchange written instructions for installation, operation and maintenance have been followed. Warranty excludes parts associated with routine maintenance, such as belts. Refer to the Airxchange Energy Recovery Cassette Limited Warranty Certificate.

2.12.7.1.4. Total energy recovery wheels shall be coated with silica gel desiccant permanently bonded by a process without the use of binders or adhesives, which may degrade desiccant performance. The substrate shall be lightweight polymer and shall not degrade nor require additional coatings for application in marine or coastal environments. Coated segments shall be washable with detergent or alkaline coil cleaner and water. Desiccant shall not dissolve nor deliquesce in the presence of water or high humidity.

2.13. **CONTROLS PANEL**

2.13.1. Units shall be factory wired and tested, and shall be certified by ETL, with C.S.A. approved components.

2.13.2. Wiring shall be in accordance with the Canadian Electrical Code, Part 1, and pertinent sections of Part 2 of the Code pertaining to specific equipment type and purpose.

2.13.3. All electrical circuits shall undergo a dielectric strength test (CSA C22.2-0), and shall be factory tested and checked as to proper function.

2.13.4. Pre-wired units shall bear an approved bilingual label with all the necessary identification marks, electrical data, and any cautions as required by the Canadian Electrical Code, Part 2.

2.13.5. Provide a system of motor control, including all necessary terminal blocks, motor contacts, motor overload protection, grounding lugs, control transformers, auxiliary contacts and terminals for the connection of external control devices or relays.

2.13.6. Automatic controls shall be housed in a control panel mounted in or on the air handling unit, which will meet the C.S.A. standard of the specific installation.

2.13.7. Provide unit mounted non-fused disconnect switch.

2.13.8. Provide factory wired GFI service receptacle. Contractor shall provide 120/1/60 power

2.14. **CONTROL SEQUENCE**

2.14.1. The new equipment shall be capable of interfacing with the existing building BAS. At the very minimum, the BAS shall be capable of:

2.14.1.1. Setting the discharged air or return air setpoint
2.14.1.2. Be capable of operating the fresh air of the equipment

2.14.2. The equipment sequences of operation shall match the ones described on the drawings (BAS diagrams)

2.14.3. Solid state analyzer complete with proportional and integral control and with a discharge air sensor to maintain set point temperature and provide rapid response to incremental changes in discharge air temperature. Combustion air motor speed varies in response to the modulation of gas flow to provide optimum fuel/air mixture and efficiency at all conditions.

2.14.4. Combustion efficiency of heat exchangers shall increase 4 – 5% from high fire to low fire on units incorporating 10:1 turndown (HT Burner). Heat exchangers shall provide a minimum of 80% efficiency throughout the entire operating range.

2.14.5. Alternate manufacturers units which do not incorporate a variable speed combustion air blower shall have a modulating gas valve and a combustion air damper with a linear linkage connected to an actuator which has a minimum of 100 steps of control.

2.14.6. Controllers shall include the following standard features:

2.14.6.1. linear gas and combustion air flow obtained via a built-in solid state linear algorithm
2.14.6.2. -40F (-40C) minimum operating ambient temperature
2.14.6.3. four (4) air change pre-purge on units with over 400 MBH (117 kw) input
2.14.6.4. post purge
2.14.6.5. interrupted pilot
2.14.6.6. self-check on start-up to make sure air proving and discharge air sensors are operating within design tolerances
2.14.6.7. low fire start
2.14.6.8. controlled burner start-up and shut down
2.14.6.9. diagnostic lights for ease of set-up and service
2.14.6.10. blower contactor that starts fan after burner pre-purge
2.14.6.11. damper contact that allows fan to start after damper opens, damper to close after fan stops and damper to close on flame failure
2.14.6.12. non-recycling auto by-pass low limit that has built-in sensor checking
2.14.6.13. built-in alternate blower and damper functions and set back temperatures for unoccupied mode operation using a single room thermostat

2.14.7. Provide a discharge air low limit equipped with an automatic by-pass time delay to allow for cold weather start-up. On a heating system failure this device will shut down the fan

and close the outdoor air damper. This device shall require automatic resetting by interrupting the electrical circuit through the BMS.

2.14.8. Provide additional dry contact points to be hardwired to BAS on site:

2.14.8.1. Unit On/Off
2.14.8.2. Heat On/Off
2.14.8.3. Cool On/Off
2.14.8.4. Setpoint adjustment 0-10VDC
2.14.8.5. VFDs 0-10VDC (where applicable)
2.14.8.6. Damper signal 0-10VDC for fresh air
2.14.8.7. Damper feedback signals
2.14.8.8. General Alarm
2.14.8.9. Burner Status
2.14.8.10. Dirty Filter indication

2.14.9. Refer also to control sequencing of system in Controls Section. BAS control components provided by controls contractor shall be field installed.

2.14.10. Adjustable frequency drive (where applicable) shall be factory supplied and installed in a NEMA 1 enclosure and shall be labeled by an approved testing agency such as UL.

2.14.11. Unit mounted manual VFD bypass switch locks out VFD, fan runs on maximum set volume. Bypass switch and all interlock contacts are factory mounted and pre-wired.

2.14.12. Line and load reactors required for all 460 and 575 volt applications.

2.14.13. For safety, minimum CFM of 35% shall be set on gas fired heat exchangers

2.15. **NON-FUSED DISCONNECT & ELECTRICAL**

2.15.1. Air-source heat pump shall include an optimized start defrost cycle to prevent frost accumulation on the outdoor coil during heat pump heating operation and to minimized defrost cycle energy usage. If the temperature of the outdoor heat exchanger and/or the suction line is less than a predetermined value, a deferred defrost cycle is initiated wherein the defrost cycle starts after a variable, continuously optimizing, time interval has elapsed. The defrost cycle is terminated when the relative temperatures of the outdoor heat exchanger and/or the suction line indicate that sufficient frost is melted from the heat exchanger to ensure adequate time between successive defrost cycles for optimizing the efficiency and reliability of the system, or after a predetermined time interval has elapsed, whichever condition occurs first. During defrost cycle all compressors shall energize, reversing valves shall de-energize, and auxiliary heat shall energize.

2.15.2. 3-pole, molded case, HACR circuit breaker with provisions for through the base electrical connections shall be factory installed. Wiring shall be from the circuit breaker to the unit high voltage terminal block.

2.15.3. The switch shall be UL/CSA agency recognized.

2.15.4. The circuit breaker will be sized as per NEC and UL guidelines.

2.15.5. Factory wired voltage/phase monitor shall be included as standard. In the event of the following the unit shall shut down and upon correction of the fault condition the unit will reset and restart automatically:

2.15.5.1. Phase unbalance protection: Factory set 2%
2.15.5.2. Over/under/brown out voltage protection: +/- 10% of nameplate voltage
2.15.5.3. Phase loss/reversal

2.16. **HAIL GUARDS**

2.16.1. Hail guards shall be installed on the outside of the condenser coil. The guards shall consist of perforated metal, of the same gauge and colour as the unit itself.

2.16.2. Airflow through the hail guards shall not be restricted due to location or size of the perforations.

2.16.3. Guards shall be removable to accommodate coil cleaning.

2.17. **CONVENIENCE OUTLET**

2.17.1. A powered 120 volt, 15 amp, 2 plug convenience outlet shall be factory installed. A service receptacle disconnect shall be installed.

2.17.2. The convenience outlet shall be powered from a dedicated power source different than the unit.

PART 3 - EXECUTION

3.1. **INSTALLATION**

3.1.1. Prior to submission of shop drawings, the manufacturer shall inspect the site and accurately measure the existing steel supports and location of roof mounted ductwork.

3.1.2. The new equipment shall accurately match the footprint of the existing one, so that no adjustment of the existing steel structure shall be necessary. All access doors shall be on sides not obstructed by ductwork or other building elements.

3.1.3. Make all connections to power, automation and gas. Connect unit to ductwork.

3.1.4. Assemble and install roof top unit components in strict accordance with manufacturer's instructions. Unit to be completely level.

3.1.5. Repair painted units by touch up of all scratches with finish paint material. Vacuum the interior of air-handling units clean prior to operation.

3.1.6. Leakage and test requirements for roof top units shall be the same as specified for ductwork except leakage shall not exceed Leakage Class (CL) 12 listed in SMACNA HVAC Air Duct Leakage Test Manual when tested at 1.5 times the design static pressure. Repair casing air leaks that can be heard or felt during normal operation and to meet test requirements.

3.1.7. Seal and/or fill all openings between the casing and RTU components and utility connections to prevent air leakage or bypass.

3.2. **STARTUP SERVICES**

3.2.1. The air handling unit shall not be operated for any purpose, temporary or permanent, until ductwork is clean, filters are in place, bearings are lubricated and fan has been test run under observation.

3.2.2. An authorized factory representative shall start up, test and certify the final installation and application specific calibration of control components. Items to be verified include fan performance over entire operating range, noise and vibration testing, verification of proper alignment, overall inspection of the installation, Board's staff training, etc.

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PART 1 - GENERAL

1.1. DESCRIPTION

1.1.1. This section applies to all sections of Division 26 - Electrical.

1.1.2. Furnish and install electrical systems, materials, equipment, and accessories in accordance with the specifications and drawings. Capacities and ratings of motors, transformers, conductors and cable, switchboards, switchgear, panelboards, motor control centers, generators, automatic transfer switches, and other items and arrangements for the specified items are shown on the drawings.

1.1.3. Electrical service entrance equipment and arrangements for temporary and permanent connections to the electric utility company's system shall conform to the electric utility company's requirements. Coordinate fuses, circuit breakers and relays with the electric utility company's system, and obtain electric utility company approval for sizes and settings of these devices.

1.1.4. Conductor ampacities specified or shown on the drawings are based on copper conductors, with the conduit and raceways sized per NEC. Aluminum conductors are prohibited.

1.2. MINIMUM REQUIREMENTS

1.2.1. Canadian Electrical Safety Code, (CESC), National Electrical Code (NEC), Underwriters Laboratories, Inc. (UL), and National Fire Protection Association (NFPA) codes and standards are the minimum requirements for materials and installation.

1.2.2. The drawings and specifications shall govern in those instances where requirements are greater than those stated in the above codes and standards.

1.3. TEST STANDARDS

1.3.1. All materials and equipment shall be listed, labeled, or certified by a Nationally Recognized Testing Laboratory (NRTL) to meet Underwriters Laboratories, Inc. (UL), standards where test standards have been established. Materials and equipment which are not covered by UL standards will be accepted, providing that materials and equipment are listed, labeled, certified or otherwise determined to meet the safety requirements of a NRTL. Materials and equipment which no NRTL accepts, certifies, lists, labels, or determines to be safe, will be considered if inspected or tested in accordance with national industrial standards, such as ANSI, NEMA, and NETA. Evidence of compliance shall include certified test reports and definitive shop drawings.

1.4. DEFINITIONS

1.4.1. Listed: Materials and equipment included in a list published by an organization that is acceptable to the Authority Having Jurisdiction and concerned with evaluation of products or services, that maintains periodic inspection of production or listed materials and equipment or periodic evaluation of services, and whose listing states that the materials and equipment either meets appropriate designated standards or has been tested and found suitable for a specified purpose.

1.4.2. Labeled: Materials and equipment to which has been attached a label, symbol, or other identifying mark of an organization that is acceptable to the Authority Having Jurisdiction and concerned with product evaluation, that maintains periodic inspection of production of labeled materials and equipment, and by who's labeling the manufacturer indicates compliance with appropriate standards or performance in a specified manner.

1.4.3. "Concealed" means hidden from normal sight in furred spaces, shafts, ceiling spaces, walls, or partitions. Wiring, raceways, and electrical boxes for all new or relocated devices shall be concealed.

1.4.4. "Exposed" means work normally visible to any person standing, sitting, or otherwise using the occupied space, including work in equipment rooms, tunnels, and similar spaces.

1.4.5. "Provide" (and all tenses) means supply and install for a complete, operational, and code-compliant system, including all devices/equipment as specified complete with wiring, raceways (conduit), electrical boxes, and all other accessories required for a complete, operational, and code compliant installation.

1.4.6. "Install" (and all tenses) means secure in position, connect as specified, test, and verify.

1.4.7. "Supply" means to supply all devices/equipment to the responsible trade.

1.4.8. "Remove" means to isolate, disconnect, disassemble, remove, and dispose of all devices, equipment, wiring, raceways, and connections to other equipment all the way to the main source. Patch and make good all surfaces affected by the removal. Include for all disposal costs in the tender price.

1.4.9. The term "approved", "approval", etc., shall be understood to mean approved by authorities having jurisdiction as conforming to Codes, Standards, By-laws, etc.

1.4.10. The term "accessible" shall be understood to mean readily accessible by a person using necessary tools but without cutting or breaking out material.

1.4.11. The term "listed" shall be understood to mean that the materials or equipment have been tested in accordance with applicable standards, and have been approved and listed for their intended use by a testing company approved by the Authorities having jurisdiction.

1.4.12. The term “listed” shall be understood to mean that the materials or equipment have been tested in accordance with applicable standards, and have been approved and listed for their intended use by a testing company approved by the Authorities having jurisdiction

1.4.13. Where used, wordings such as "approved, to approval, as directed, permitted, permission, accepted, acceptance", shall mean: approved, directed, permitted, accepted, by an authorized representative of the Owner. and Install: material, equipment and labor shall be provided as required to make the equipment or system fully operational. Include all required wiring, conduit and other electrical devices as required, whether shown on the drawings, specified herein or not.

1.4.14. Certified: Materials and equipment which:

1.4.14.1. Have been tested and found to meet nationally recognized standards or to be safe for use in a specified manner.

1.4.14.2. Bear a label, tag, or other record of certification.

1.5. **QUALIFICATIONS (PRODUCTS AND SERVICES)**

1.5.1. Manufacturer’s Qualifications: The manufacturer shall regularly and currently produce, as one of the manufacturer's principal products, the materials and equipment specified for this project, and shall have manufactured the materials and equipment for at least three years.

1.5.2. Product Qualification:

1.5.2.1. Manufacturer's materials and equipment shall have been in satisfactory operation, on three installations of similar size and type as this project, for at least three years.

1.5.2.2. Service Qualifications: There shall be a permanent service organization maintained or trained by the manufacturer which will render satisfactory service to this installation within eight hours of receipt of notification that service is needed. Submit name and address of service organizations.

1.6. **APPLICABLE PUBLICATIONS, CODES AND STANDARDS**

1.6.1. Applicable publications listed in all Sections of Division 26 are the latest issue, unless otherwise noted.

1.6.2. Products specified in all sections of Division 26 shall comply with the applicable publications listed in each section.

1.6.3. Publications:

1.6.3.1. CAN/CSA C22.1-015, Canadian Electrical Code Part 1 (23nd Edition), Safety Standard for Electrical Installations.
1.6.3.2. Ontario Electrical Safety Code 26th Edition / 2015 or later.
1.6.3.3. CAN3-C235-83 (R2010), Preferred Voltage Levels for AC Systems, 0 to 50,000V.
1.6.3.4. National Building Code of Canada.
1.6.3.5. National Fire Code of Canada.
1.6.3.6. Ontario Building Code 2012.
1.6.3.7. National Fire Protection Code NFPA-70

1.7. **MANUFACTURED PRODUCTS**

1.7.1. Materials and equipment furnished shall be of current production by manufacturers regularly engaged in the manufacture of such items, and for which replacement parts shall be available.

1.7.2. When more than one unit of the same class or type of materials and equipment is required, such units shall be the product of a single manufacturer.

1.7.3. Equipment Assemblies and Components:

1.7.3.1. Components of an assembled unit need not be products of the same manufacturer.
1.7.3.2. Manufacturers of equipment assemblies, which include components made by others, shall assume complete responsibility for the final assembled unit.

1.7.4. Components shall be compatible with each other and with the total assembly for the intended service.

1.7.5. Constituent parts which are similar shall be the product of a single manufacturer.

1.7.6. Factory wiring and terminals shall be identified on the equipment being furnished and on all wiring diagrams.

1.7.7. When Factory Testing Is Specified:

1.7.7.1. The Board shall have the option of witnessing factory tests. The Contractor shall notify the Board a minimum of 15 working days prior to the manufacturer's performing the factory tests.
1.7.7.2. When materials and equipment fail factory tests, and re-testing and re-inspection is required, the Contractor shall be liable for all additional expenses for the Board to witness re-testing.

1.8. **VARIATIONS FROM CONTRACT REQUIREMENTS**

1.8.1. Where the Board or the Contractor requests variations from the contract requirements, the connecting work and related components shall include, but not be limited to additions or changes to branch circuits, circuit protective devices, conduits, wire, feeders, controls, panels and installation methods.

1.9. **MATERIALS AND EQUIPMENT PROTECTION**

1.9.1. Materials and equipment shall be protected during shipment and storage against physical damage, vermin, dirt, corrosive substances, fumes, moisture, cold and rain.

1.9.2. Store materials and equipment indoors in clean dry space with uniform temperature to prevent condensation.

1.9.3. During installation, equipment shall be protected against entry of foreign matter, and be vacuum-cleaned both inside and outside before testing and operating. Compressed air shall not be used to clean equipment. Remove loose packing and flammable materials from inside equipment.

1.9.4. Damaged equipment shall be repaired or replaced, as determined by the Consultant.

1.9.5. Painted surfaces shall be protected with factory installed removable heavy kraft paper, sheet vinyl or equal.

1.9.6. Damaged paint on equipment shall be refinished with the same quality of paint and workmanship as used by the manufacturer so repaired areas are not obvious.

1.10. **WORK PERFORMANCE**

1.10.1. All electrical work shall comply with the requirements of CESC, NFPA 70 (NEC), NFPA 70B, NFPA 70E, OSHA Part 1910 subpart J – General Environmental Controls, OSHA Part 1910 subpart K – Medical and First Aid, and OSHA Part 1910 subpart S – Electrical, in addition to other references required by contract.

1.10.2. Job site safety and worker safety is the responsibility of the Contractor.

1.10.3. Electrical work shall be accomplished with all affected circuits or equipment de-energized. When an electrical outage cannot be accomplished in this manner for the required work, the following requirements are mandatory:

1.10.4. Electricians must use full protective equipment (i.e., certified and tested insulating material to cover exposed energized electrical components, certified and tested insulated tools, etc.) while working on energized systems in accordance with NFPA 70E.

1.10.5. Work on energized circuits or equipment cannot begin until prior written approval is obtained from the Consultant

1.10.6. For work that affects existing electrical systems, arrange, phase and perform work to assure minimal interference with normal functioning of the facility.

1.10.7. New work shall be installed and connected to existing work neatly, safely and professionally. Disturbed or damaged work shall be replaced or repaired to its prior conditions.

1.10.8. Coordinate location of equipment and conduit with other trades to minimize interference.

1.11. **COORDINATION AND INTERFERENCE DRAWINGS**

1.11.1. Provide information and cooperate with the General/Mechanical Contractor for the preparation of interference and coordination drawings.

1.11.2. Interference and coordination drawings to be provided in order to make clear the Work intended or to show how it affects other trades.

1.11.3. Interference and coordination drawings to be provided for:

1.11.3.1. Mechanical, Electrical, Communications Rooms
1.11.3.2. Service corridors and tunnels
1.11.3.3. Corridor, lobbies and all public spaces
1.11.3.4. Crawl spaces
1.11.3.5. Attic spaces
1.11.3.6. Underground Trenches
1.11.3.7. Raised floor spaces

1.12. **EQUIPMENT INSTALLATION AND REQUIREMENTS**

1.12.1. Equipment location shall be as close as practical to locations shown on the drawings.

1.12.2. Working clearances shall not be less than specified in the CEC.

1.12.3. Inaccessible Equipment:

1.12.3.1. Where the Consultant determines that the Contractor has installed equipment not readily accessible for operation and maintenance, the equipment shall be removed and reinstalled as directed at no additional cost to the Board.
1.12.3.2. "Readily accessible" is defined as being capable of being reached quickly for operation, maintenance, or inspections without the use of ladders, or without climbing or crawling under or over obstacles such as, but not limited to, motors, pumps, belt guards, transformers, piping, ductwork, conduit and raceways.

1.12.4. Electrical service entrance equipment and arrangements for temporary and permanent connections to the electric utility company's system shall conform to the electric utility

company's requirements. Coordinate fuses, circuit breakers and relays with the electric utility company's system, and obtain electric utility company approval for sizes and settings of these devices.

1.13. **EQUIPMENT IDENTIFICATION**

1.13.1. In addition to the requirements of the CEC, install an identification sign which clearly indicates information required for use and maintenance of items such as switchboards and switchgear, panelboards, cabinets, motor controllers, fused and non-fused safety switches, generators, automatic transfer switches, separately enclosed circuit breakers, individual breakers and controllers in switchboards, switchgear and motor control assemblies, control devices and other significant equipment.

1.13.2. Identification signs for Normal Power System equipment shall be laminated black phenolic resin with a white core with engraved lettering. Identification signs for Essential Electrical System (EES) equipment, as defined in the NEC, shall be laminated red phenolic resin with a white core with engraved lettering. Lettering shall be a minimum of 12 mm (1/2 inch) high. Identification signs shall indicate equipment designation, rated bus amperage, voltage, number of phases, number of wires, and type of EES power branch as applicable. Secure nameplates with screws.

1.13.3. Install adhesive arc flash warning labels on all equipment as required by NFPA 70E. Label shall indicate the arc hazard boundary (inches), working distance (inches), arc flash incident energy at the working distance (calories/cm2), required PPE category and description including the glove rating, voltage rating of the equipment, limited approach distance (inches), restricted approach distance (inches), prohibited approach distance (inches), equipment/bus name, date prepared, and manufacturer name and address.

1.14. **SUBMITTALS**

1.14.1. All submittals shall include copies of adequate descriptive literature, catalog cuts, shop drawings, test reports, certifications, samples, and other data necessary for the Board to ascertain that the proposed materials and equipment comply with drawing and specification requirements. Catalog cuts submitted for approval shall be legible and clearly identify specific materials and equipment being submitted.

1.14.2. Submittals for individual systems and equipment assemblies which consist of more than one item or component shall be made for the system or assembly as a whole. Partial submittals will not be considered for approval.

1.14.3. The Consultant's approval shall be obtained for all materials and equipment before delivery to the job site. Delivery, storage or installation of materials and equipment which has not had prior approval will not be permitted.

1.14.4. The submittals shall include the following:

1.14.4.1. Information that confirms compliance with contract requirements. Include the manufacturer's name, model or catalog numbers, catalog information, technical data sheets, shop drawings, manuals, pictures, nameplate data, and test reports as required.

1.14.4.2. Elementary and interconnection wiring diagrams for communication and signal systems, control systems, and equipment assemblies. All terminal points and wiring shall be identified on wiring diagrams.

1.14.4.3. Parts list which shall include information for replacement parts and ordering instructions, as recommended by the equipment manufacturer.

1.14.5. Maintenance and Operation Manuals:

1.14.5.1. Submit as required for systems and equipment specified in the technical sections. Furnish in hardcover binders or an approved equivalent.

1.14.5.2. Inscribe the following identification on the cover: the words "MAINTENANCE AND OPERATION MANUAL," the name and location of the system, material, equipment, building, name of Contractor, and contract name and number. Include in the manual the names, addresses, and telephone numbers of each subcontractor installing the system or equipment and the local representatives for the material or equipment.

1.14.5.3. Provide a table of contents and assemble the manual to conform to the table of contents, with tab sheets placed before instructions covering the subject. The instructions shall be legible and easily read, with large sheets of drawings folded in.

1.14.6. The manuals shall include:

1.14.6.1. Internal and interconnecting wiring and control diagrams with data to explain detailed operation and control of the equipment.

1.14.6.2. A control sequence describing start-up, operation, and shutdown.

1.14.6.3. Description of the function of each principal item of equipment.

1.14.6.4. Installation instructions.

1.14.6.5. Safety precautions for operation and maintenance.

1.14.6.6. Diagrams and illustrations.

1.14.6.7. Periodic maintenance and testing procedures and frequencies, including replacement parts numbers.

1.14.6.8. Performance data.

1.14.6.9. Pictorial "exploded" parts list with part numbers. Emphasis shall be placed on the use of special tools and instruments. The list shall indicate sources of supply, recommended spare and replacement parts, and name of servicing organization.

1.14.6.10. List of factory approved or qualified permanent servicing organizations for equipment repair and periodic testing and maintenance, including addresses and factory certification qualifications.

1.14.6.11. Approvals will be based on complete submission of shop drawings, manuals, test reports, certifications, and samples as applicable.

1.15. **RECORD DRAWINGS**

1.15.1. The Consultant will provide to the Electrical Contractor one set of AutoCad computer files and one set of white prints of all drawings relating to the work of this contract, for the purpose of preparing record drawings. As the job progresses, mark up the white prints to accurately indicate installed work, i.e. location and elevations, etc. On completion of the work, the Electrical Contractor to transfer the information neatly onto the computer files based on AutoCad 2007 or higher, and submit the electronic files and one set of prints for review and comment. Correct the files as directed by the Consultant and hand these over to the Board, together with a set of white prints, on completion.

1.15.2. Record, as the job progresses, all approved changes and deviations made to any work shown on the original contract drawings whether by addenda, requested changes, job instructions, and changes due to job conditions.

1.15.3. Indicate on the drawings all conduits, pull boxes, junction boxes, empty conduits, concealed main and sub-feeder conduits and any other equipment not clearly in view, with exact dimensions for future reference. Tie dimensions by measurement to existing topographical features, and include changes in directions as well as at least three points on straight runs of conduits on raceways.

1.15.4. All conduits in slabs, under slab and direct buried are to be shown on the Record drawings.

1.15.5. Record drawings to be kept up to date and be available for checking at any time by Boards and Consultant. Progress draws will not be reviewed unless the record drawing set is up to date.

1.15.6. All equipment schedules, panel schedules, system schedules, riser diagrams, details, etc. to be updated to reflect the as installed condition and included as part of the record drawing submission.

1.15.7. Provide a schedule indicating the protective device trip setting of all Air Circuit Breakers and Electronic Solid State Circuit Breakers which are reflected on each of the Power Distribution Single Line Riser Diagram drawings. The protective device trip settings that are to be listed in the schedule are to be those which are based upon the final reviewed and accepted version of the short circuit and protection and coordination as well as the arc flash study.

1.15.8. Branch circuiting, lighting zoning, switching, etc. methodology to be the same as that indicated on the electrical contract documents that are issued for construction.

1.15.9. Electrical record drawings to be submitted in both AutoCad and PDF format.

1.15.10. Record drawings will not be reviewed for acceptance until project substantial completion has been issued.

1.16. **ACCEPTANCE CHECKS AND TESTS**

1.16.1. The Contractor shall furnish the instruments, materials, and labor for tests.

1.16.2. Where systems are comprised of components specified in more than one section of Division 26, the Contractor shall coordinate the installation, testing, and adjustment of all components between various manufacturer's representatives and technicians so that a complete, functional, and operational system is delivered to the Board.

1.16.3. When test results indicate any defects, the Contractor shall repair or replace the defective materials or equipment, and repeat the tests. Repair, replacement, and retesting shall be accomplished at no additional cost to the Board.

1.17. **CODES, PERMITS AND INSPECTIONS**

1.17.1. All work to meet or exceed the latest requirements of the Codes and Standards as listed in PART 1 of these specifications, supplements, local inspection bulletins and all Authorities Having Jurisdiction.

1.17.2. Arrange for inspection of all work and pay all fees in this regard. On completion of the work, deliver the final unconditional certificate of approval of the Electrical Safety Authority (ESA).

1.17.3. It is hereby agreed that all requirements meet CAN/CSA requirements and a complete installation in accordance with these requirements to be provided.

1.17.4. Keep a permanent record of each inspection made by the Electrical Safety Authority showing the date, inspector's name, scope of the inspection and statement of special decisions or permissions granted. Make these records available to the Consultant at any time, and turn them over at completion of the work.

1.18. **WARRANTY**

1.18.1. All work performed and all equipment and material furnished under this Division shall be free from defects and shall remain so for a period of one year from the date of acceptance of the entire installation by the Board's representative.

1.19. **INSTRUCTION**

1.19.1. Instruction to designated Board personnel shall be provided for the particular equipment or system as required in each associated technical specification section.

1.19.2. Furnish the services of competent instructors to give full instruction in the adjustment, operation, and maintenance of the specified equipment and system, including pertinent safety requirements. Instructors shall be thoroughly familiar with all aspects of the installation, and shall be trained in operating theory as well as practical operation and maintenance procedures.

1.19.3. A training schedule shall be developed and submitted by the Contractor and approved by the Consultant at least 15 days prior to the planned training.

PART 2 - PRODUCTS

2.1. **MATERIALS AND EQUIPMENT**

2.1.1. All materials and equipment to be new and free from defects.

2.1.2. All material and equipment to be CAN/CSA certified. Where CAN/CSA certified material and equipment is not available, obtain special approval from authority having jurisdiction before delivery to site and submit such approval as described in PART 1 - SUBMITTALS.

2.1.3. Where materials, equipment, apparatus, or other products are specified by the manufacturer, brand name, type or catalogue number, such designation is to establish the standards of desired quality, style or dimensions and to be the basis of the Bid. Furnish materials so specified under this Contract unless changed by mutual agreement. Where two or more designations are listed, the Electrical Contractor to choose one of those listed.

2.1.4. Where the use of equivalent, alternate or substitute equipment alters the design or space requirements indicated on the plans, the Electrical Contractor for this contract to include all items of cost for the revised design and construction, including the cost of all the other trades involved.

2.1.5. Acceptance of the proposed equivalents, alternates or substitutions to be subject to the review by the Consultant, and if requested, the Electrical Contractor to submit for inspection, samples of both the specified and the proposed alternate items.

2.1.6. In all cases where the use of equivalents, alternates or substitutions is permitted, the Electrical Contractor to bear any extra costs of evaluating the quality of materials and the equipment to be installed.

2.2. **EQUIVALENTS AND ALTERNATES**

2.2.1. Should the Electrical Contractor propose to furnish material and equipment other than those specified, he is to apply in writing to the Consultant for approval of equivalents at least ten working days prior to the closing of Bids, submitting with his request for approval, complete descriptive and technical data on the item or items he proposes to furnish. Approval for changes in the base bid specifications will be considered only upon the individual requests of the Electrical Contractor. No blanket approval for equipment will be given to suppliers, distributors or contractors.

2.2.2. Unless requests for changes in base bid specifications are received and approved prior to the opening of the bids, as defined above, the Electrical Contractor will be held to furnish all specified items under his base bid. After the Contract is awarded, changes in specifications will be made only as defined in the Article dealing with Material Substitution.

2.2.3. Replace unspecified materials or rejected equivalents and alternates built into the work with specified or accepted materials at no additional cost to the Owner.

2.2.4. If any material or equipment being considered for substitution involves additional design, architectural or engineering fees or other costs in checking whether or not the substitute material or equipment is suitable for the project, such fees or costs to be paid for by the Electrical Contractor. A minimum of five hundred dollars ($500.00) to be applied to each piece of device or equipment requested for review. There is no guarantee that the reviewed product will be accepted by the Board or the reviewing Consultant.

2.3. **MATERIAL SUBSTITUTION**

2.3.1. After award of the Contract, requests for substitution of materials of makes other than those specifically named in the Contract Documents may be considered by the Consultant subject to the following:

2.3.1.1. The specified material cannot be delivered to the job in time to complete the work in proper sequence to work of other trades, due to conditions beyond the control of the Electrical Contractor.

2.3.1.2. Requests for substitutions to be accompanied by documentary proof of equality, difference in price and delivery, if any, in the form of certified quotations from suppliers of both specified and proposed equipment.

2.3.1.3. In case of difference in price, the Owner is to receive all benefit of the difference in cost involved in any substitution and the Contract altered by change order to credit the Owner with any savings so obtained.

2.3.1.4. Materials and equipment substituted or offered as alternatives to have spare parts and servicing available and to fit into the space allocation shown on the drawings.

2.3.1.5. If any material or equipment being considered for substitution involves additional design, architectural or engineering fees or other costs in checking whether or not the substitute material or equipment is suitable for the project, such fees or costs to be paid for by the Electrical Contractor. A minimum of five hundred dollars ($500.00) to be applied to each piece of device or equipment requested for review. There is no guarantee that the reviewed product will be accepted by the Board or the reviewing Consultant.

2.4. **WARNING SIGNS**

2.4.1. Warning Signs: in accordance with requirements of Authority Having Jurisdiction and Consultants.

2.4.2. Comply with Health Canada/Workplace Hazardous Materials Information System (WHMIS).

2.4.3. Provide warning labels in both English and French where project requires.

2.5. **FINISHES**

2.5.1. Shop finish metal enclosure surfaces by application of rust resistant primer inside and outside, and two coats of finish enamel.

2.5.2. Paint outdoor electrical distribution equipment green finish to EEMAC Y1-2.

2.5.3. Paint indoor normal power distribution equipment enclosures light grey to EEMAC 2Y-1.

2.5.4. Paint indoor emergency power "Life Safety" distribution equipment enclosures Red.

2.5.5. Paint indoor emergency power "Non-life Safety" distribution equipment enclosures International Orange, RAL #2009.

2.5.6. Paint indoor UPS power distribution equipment enclosures Blue, RAL #5017.

2.6. **CAN/CSA/NEMA RATING**

2.6.1. All electrical equipment provided for this project to be CAN/CSA/NEMA Rated only. IEC Rated equipment is not acceptable and will not be accepted.

PART 3 - EXECUTION

3.1. **INSTALLATION**

3.1.1. Comply with all Codes and Standards listed in PART 1 – GENERAL.

3.1.2. Comply with manufacturer's written data, including product technical bulletins, product catalog installation instructions, product carton installation instructions, MSDS, and product datasheets.

3.1.3. Protect electrical equipment from dust and dirt. Plug or cap openings of conduits, fixtures and equipment during construction with approved materials for such use.

3.1.4. The Electrical Contractor to be responsible for the layout of the work of this contract, and for any damage caused to site or existing building, or other Contracts by improper location or carrying out of this work.

3.1.5. Ensure the prompt installation of the work of this contract in advance of concrete pouring or similar work.

3.1.6. No conduits for any power or systems to be permitted to be installed within the concrete slabs or concrete walls for this project except in select identified areas as per the drawings and specifications.

3.1.7. Furnish items to be "built-in" in ample time and give any necessary information and assistance in connection with the building-in of the same.

3.1.8. Manufactured products supplied with instructions for their use to be used in strict accordance with those instructions.

3.1.9. Ensure that all equipment and material is ordered in time to meet the building schedule. Provide a schedule of equipment deliveries to the Construction Manager within the time limit stipulated.

3.2. **SITE SERVICES**

3.2.1. Site services: acquire a full working knowledge of the building site, services and any existing conditions thereon that may impact the project implementation. Review and examine the contract drawings and schedules of all trades prior to bid submittal to ensure full knowledge of the contract scope of work is ascertained.

3.2.2. The location of equipment indicated or specified is considered approximate. Review proposed locations with Consultant prior to installation.

3.2.3. Locate equipment, piping, duct and/or conduit to provide minimum interference and maximum usable space and in accordance with manufacturer's recommendations for safety, access and maintenance.

3.3. **CONTRACTOR'S SHOP**

3.3.1. Provide job site office, workshop, tools, scaffolds, material storage, etc., as required to complete the work of this contract and as directed by the Consultant.

3.3.2. The electrical contractor's office should as a minimum have the following capabilities, Phone, fax, email, High speed internet connection, router with a spare port and patch cable in order that the consultant can access the internet to deal with project related issues, copier and printer.

3.4. **TEMPORARY SERVICES**

3.4.1. Provide temporary electrical services with all poles, transformer and protection equipment from the locations as coordinated with the Owner. Provide all power panels at various locations on the site required to perform the work and as specified by the Consultant. All temporary services must be coordinated with the Owner. Do not use the permanent service of new or existing building for temporary power for construction unless specific written approval is obtained from the Consultant and coordinated with the Board

3.5. **ACCESS TO ELECTRICAL EQUIPMENT, JUNCTION BOXES AND PULL BOXES**

3.5.1. Clear access of a minimum of 1 meter must be provided for all electrical equipment, junction boxes and pull boxes.

3.5.2. All junction boxes and pull boxes to be within 600mm of an access panel or access luminaire and be easily accessed.

3.5.3. All electrical boxes that have free sides (IE: no conduits entering or leaving a side) to be kept clear in order to permit installation of conduits at a later date. Hence free sides of all electrical boxes to be clear of other conduits and services.

3.6. **NAMEPLATES**

3.6.1. Ensure manufacturer's nameplates, CAN/CSA labels and identification nameplates are visible and legible after equipment is installed.

3.7. **LOCK OFF TABS**

3.7.1. Provide lock off tabs on all panel boards for circuits that serve:

3.7.1.1. Emergency lighting;
3.7.1.2. Exit lighting;
3.7.1.3. Fire alarm equipment
3.7.1.4. Security equipment.

3.8. **FIRESTOPPING**

3.8.1. Where cables, sleeves or conduits, pass through floors and fire rated walls pack space between wiring and sleeve or opening and seal with Hilti fire stopping system that is appropriate. The fire stopping installation must meet one of the approved details as

required to meet the rating of the assembly. Contact the Hilti representative to ensure that the installation meet Hilti requirements.

3.8.2. Care must be taken to keep integrity of all assemblies and maintain good finishes of surrounding areas, use tape for finish at edges when apply fire stopping materials. Provide at the end of the project a letter from Hilti indicating that the installation meets all requirements.

3.8.3. Meet all requirements of the Codes and fire proofing requirements as specified within the Contract Documents.

3.8.4. Provide Shop drawings for the various Fire stopping assemblies that will be utilized on the project to achieve the fire rating for construction assemblies or methods.

3.8.5. Refer (where applicable) to architectural drawings for fire separation diagrams. Such drawings may not be issued as part of the electrical documents; it is the electrical contractor's obligation to review all contract documentation of all involved disciplines (drawings and specifications).

3.9. **BASES AND SUPPORTS**

3.9.1. Where conduit and equipment are located on walls or slabs which will not permit the support of equipment, provide suitable supports to the building structure. Supports to be constructed of steel members or of steel pipe and fittings designed to safely support the equipment.

3.9.2. All equipment bases to be set on pads of kinetic pre-compressed fiberglass or vibration isolators sized to suit the equipment which they ought to support.

3.10. **INSERTS, SLEEVES AND CURBS**

3.10.1. Provide all inserts, sleeves and curbs required for the work of this contract.

3.10.2. Use only factory made threaded or toggle type inserts as required for support and anchors, properly sized for the load to be carried. Place inserts only in portions of the main structure and not in any finishing material.

3.10.3. Use factory made expansion shields where inserts cannot be placed, but only where approved by the Structural Engineer and only for loads of 50 kg or less.

3.10.4. Do not use powder activated tools unless with written permission of the Board’s Representative.

3.10.5. Supply and locate all inserts, holes, anchor bolts and sleeves in time when walls, floors and roof are erected.

3.10.6. Size sleeves to provide 25 mm clearance all around.

3.10.7. Pack all sleeves between the conduit or cable passing through the sleeve and the sleeve and all spare sleeves with loose fiberglass insulation. Seal the annular space both sides as follows:

3.10.7.1. For all horizontal sleeves in exposed areas, use a seal of equal or better fire rating than the wall to be sealed.

3.10.7.2. For all horizontal concealed sleeves through fire walls and through walls separating areas of different air pressure, use a permanently resilient silicone base or equal sealing compound.

3.10.7.3. For all vertical sleeves through roofs, washrooms, janitor closets, equipment rooms, use permanently resilient silicone base or equal compound, non-flammable and waterproof. Ensure that the seal is compatible with floor and ceiling finishes. Check the room finishes schedules for further information.

3.11. **CUT PATCH AND MAKE GOOD**

3.11.1. All drilling, cutting, patching, concrete curbs, housekeeping pads and similar work required for installation of the specified systems shall be done under this contract.

3.11.2. Do not use powder actuated tools using explosives, unless permitted expressly by the Board in writing.

3.11.3. All cutting of steel shall be by mechanical cutters or saws. Torches and abrasives will only be permitted if there is no alternative. Prior to using torches or abrasives obtain Hot Work Permit in accordance with the Board's hot work procedure.

3.11.4. Scan the walls/floor slabs using ground penetrating radar (GPR) technology prior to making openings to determine the presence and location of embedded conduits or rebar. Clean the floors/walls immediately after core drilling/saw cutting is complete. All core drilling and loud and/or prolonged drilling shall be done after normal working hours (during silent hours) or as permitted by the "hammer drilling" schedule and 48 hour lead notice is to be provided to the building Owner to confirm contractor has met all mandatory conditions.

3.11.5. Core drilling through floors and walls shall be done with diamond drills only. The use of pneumatic hammers will not be permitted.

3.11.6. Patch and make good all surfaces cut, damaged or disturbed to the Board 's approval. Match existing material, colour, finish and texture.

3.11.7. Welding and cutting: conform to Ontario Health and Safety Act O.Reg. 213/91 amended to O.Reg. 628/05 Construction Projects. Obtain a Hot Work Permit from the PM prior to welding and cutting operations. Follow the PM's hot work procedures.

3.11.8. Do not dispose of cement, mortar, plaster or other similar materials into drainage system. Contractor shall be liable for all costs associated with cleanup and reinstatement to original condition after doing so.

3.11.9. Dispose of sediment-containing liquids such as those resulting from core drilling or concrete cutting into designated drains. Flush drain with sufficient quantity of clean water to ensure that drain is free-flowing and unobstructed. Be liable for all costs associated with cleanup and reinstatement of drain and piping to original condition if found to be blocked by sediment.

3.11.10. Firestop all penetrations through wall and floor assemblies with Hilti Firestop solutions having a fire resistance rating not less than the assembly penetrated, colour: red. Unless otherwise noted, use the following assembly ratings: floors 2-hours; walls except around stairways – 1½ hours; walls around stairways: 2 – hours. Submit to Consultant for approval the proposed system detail sheets bearing the UL/CUL system number. Provide specified firestopping compound on both sides of assembly penetrated regardless of UL/CUL detail requirements.

3.12. **REMOVALS AND DEMOLITION**

3.12.1. The drawings indicate the general scope of electrical removals. Verify on site the exact requirements and extent of removals.

3.12.2. Visit the site to determine the extent of all removals.

3.12.3. Maintain, retain and make good as required all existing systems, branch wiring and feeders intended to remain operational in areas which are affected by these renovations.

3.12.4. Schedule all demolition work with project manager prior to any service interruption in occupied building area.

3.12.5. All shutdowns of existing base building systems shall be coordinated with the Board's representative. Pay for any cost incurred. All building services to remain fully operational during construction. Include in tender for off hours to install new breaker in existing panels and connection for feeders.

3.12.6. Remove electrical equipment as required complete with wiring up to associated panel. Remove all electrical components to be demolished or to be relocated and make safe all wiring. Hand over removed items to owner if requested. Dispose of the equipment properly which Owner does not wish to retain. Update existing panel directory which is affected.

3.12.7. Inform the Consultant and the Board immediately if any contaminated materials are found on site. Remove the items so that they can be packed and removed from the site. Provide assistance and cooperation for the complete removal.

3.12.8. The contractor shall be responsible to relocate any existing electrical equipment and/or wiring that will interfere with new construction.

3.12.9. The contractor shall be responsible for reconnection of any services that are to remain and have been disconnected during the course of demolition or construction.

3.12.10. All systems and components which are affected by the renovation shall remain operational subsequent to project completion. Reinstate immediately any services disrupted during demolition not intended to be removed as part of this contract at no extra cost.

3.12.11. Retain continuity of service of the fire alarm system to all occupied areas of the building.

3.12.12. The contractor shall advise security in the event that fire alarm system continuity is disrupted such that a fire watch can commence immediately.

3.12.13. Repair all damages inside and outside of the renovated areas caused by the demolition/construction without extra cost to the Owner.

3.13. **REMOVED MATERIAL**

3.13.1. All material removed during demolition shall become the property of the Contractor. The contractor shall remove material from the site and dispose of in accordance with provincial regulations. Under no circumstances is the contractor to use the building Owner's refuse containers for disposal.

3.14. **NUMBER AND LOCATION OF OUTLETS**

3.14.1. Provide outlets for power and systems of the number and in the locations shown on the drawings. Locate all outlets accurately with respect to building lines and in centering outlets due allowance to be made for overhead pipes, ducts, equipment and for variations in wall or ceiling finishes, window trim, paneling, etc. When necessary, make adjustments to ensure that all outlets are properly centered.

3.14.2. The location of any outlet may be changed without extra cost or credit providing that the new location is within 6 metres (20 feet) of that originally shown on the drawings and that instructions for the change are issued before installation of the outlet.

3.14.3. Do not mount outlet boxes in walls and partitions back-to-back and provide a minimum of 150 mm (6 inch) between boxes. Provide acoustic insulating medium in conduits which join boxes on opposite sides of same wall or partition. Acoustic properties of the wall to be matched or exceeded. Where applicable, for acoustically sensitive/critical rooms, more spacing separation and acoustic box seal is required. Refer to acoustic specifications and electrical drawings for detailed requirements.

3.15. **MOUNTING HEIGHTS**

3.15.1. The mounting height of equipment is measured from the finished floor to the centerline of the equipment unless specified or otherwise indicated.

3.15.2. If the mounting height of any equipment is not indicated, verify the mounting height before proceeding with the installation.

3.15.3. Install electrical equipment at the following mounting heights unless otherwise detailed or indicated. Refer to Architectural reflected ceiling plans, elevations, sections and details for final device location and to confirm all mounting heights.

3.15.4. All device mounting heights and orientation to be coordinated and confirmed by the Prime Consultant prior to installation.

3.15.4.1. Local switches and control devices: 1100 mm (42 inch)
3.15.4.2. Wall receptacles:
3.15.4.2.1. General: 400 mm (15 inch)
3.15.4.2.2. Above top of counters or backsplash: 175 mm (7 inch)
3.15.4.2.3. In mechanical rooms: 1400 mm (55 inch)

3.15.5. Panelboards:

3.15.5.1. 1800 mm (70 inch) to the top except that the panelboard not to be lower than 150 mm (6 inch) above the floor.
3.15.5.2. Where multiple panelboards are mounted together, align the tops of all the panelboards or trims with the highest panelboard determining the height.

3.15.6. Fire alarm system pull stations: 1200 mm (48 inch)

3.15.6.1. Fire alarm system speakers/strobes: 2300 mm (90 inch) and at least 150 mm (6 inch) below the ceiling measured to the top of device, or on ceiling.
3.15.6.2. Fire Alarm System end of line resistors as per code requirements. EOL resistors to be grouped in service spaces.
3.15.6.3. Fire fighter's phone: 1400 mm (55 inch) measured to the centerline of the enclosure.

3.15.7. Individual starters:

3.15.7.1. 1500 mm (60 inch) to the top.
3.15.7.2. Where multiple starters are mounted together, align the tops of all the starters or trims with the highest starter determining the height.

3.15.8. Splitters: 100 mm (4 inch) below the lowest equipment connected to the splitter.

3.16. **MECHANICAL AND ELECTRICAL CO-ORDINATION OF RESPONSIBILITIES**

3.16.1. The following is a list of mechanical and electrical responsibilities for the above mentioned project:

3.16.1.1. The Electrical Contractor to provide all starters or combinations starters/disconnects (fused or non-fused, as specified) for Mechanical Motors along with Line and Load side power wiring with the exception of Packaged Mechanical Equipment or Units.

3.16.1.2. Where so specified, Packaged Mechanical Equipment to be provided with its own integral disconnect(s), starters(s) or unit mounted VFD(s). With respect to Packaged Mechanical Equipment or Units the Electrical Contractor to provide the Line Side power wiring and connection(s) to the equipment connection point(s).

3.16.1.3. The Electrical Contractor to provide equipment isolation disconnect switches for all remote mechanical equipment unless otherwise indicated within the Mechanical Contract Documents or unless equipment is already furnished with a local disconnect. Where applicable, weather-proof enclosures shall be used. Remote definition: not in sight, as per NFPA-70 article 430.102

3.16.1.4. All BAS equipment and devices, to be supplied by the BAS vendor and installed by the mechanical Contractor.

3.16.1.5. The Mechanical Contractor to provide all control wiring, BAS wiring, and 120 volt control wiring for Mechanical Equipment or Units.

3.16.1.6. The Mechanical Contractor to provide all motors.

3.16.1.7. The Electrical Contractor to provide all fire alarm interface wiring to the Mechanical Equipment or Units for fire alarm Fan Shut Down, Fan Start-up as and for fire alarm Smoke Control.

3.16.1.8. The Electrical Contractor to provide all fire alarm wiring.

3.16.1.9. The Electrical Contractor to provide all relays for interface to control wiring for fan shutdown and fan start up for air handling units used as part of the smoke control system(s).

3.16.1.10. The Mechanical Contractor to provide all relays as required by the Mechanical Equipment or Units to connect to the various building systems.

3.16.1.11. The Mechanical Contractor to provide electric pipe heat tracing which to be based upon the self-limited type and be at 208 volts 1 Phase. The Electrical Contractor to provide 208 volts 1 Phase power connection(s) for the electric pipe heat tracing system(s). The Mechanical Contractor to provide loads requirements of the heat tracing to the Electrical Contractor prior to final power connection.

3.16.1.12. The Mechanical Contractor to provide electric heating, associated controls and control wiring. The Electrical Contractor to provide the Line Side power connection to the electric heating. The Mechanical Contractor to provide any framing required for recessed electric heating.

3.16.1.13. Separate Variable Frequency Drives (VFDs) to be provided by the Mechanical Contractor. Should the Mechanical Contractor change or modify motor sizes from

what is specified within the Bid Documents during any stage of this project the Mechanical Contractor will be responsible to cover all associated electrical costs such as revised motor starter and feeds, etc.

3.17. **FLASHING**

3.17.1. Coordinate with requirements for roofing, waterproofing and flashing with the Roofing Contractor.

3.17.2. Flash electrical parts passing through or built into a roof, an outside wall or a waterproof floor.

3.17.3. Provide 8-pound sheet lead flashing for cast iron or wrought iron sleeves passing through roof.

3.17.4. Flashing shall suit roof angle and shall extend minimum 450 mm (18 inch) on all sides. Leave flashing as directed by the Roofing Contractor for him to build into roofing, rendering a watertight connection.

3.17.5. Provide counter flashing on stacks, ducts and pipes passing through roof to fit over flashing or curb.

3.17.6. Provide sleeves passing through outside walls with lead or copper flashing as directed.

3.18. **SYSTEM STARTUP**

3.18.1. Inform Consultant and operating personnel in operation, care and maintenance of systems, system equipment and components.

3.18.2. Arrange and pay for services of manufacturer's factory service engineer to supervise start-up of installation, check, adjust, balance and calibrate components and instruct operating personnel.

3.18.3. Provide these services for such period, and for as many visits as necessary to put equipment in operation, and ensure that operating personnel are conversant will aspects of its care and operation.

3.19. **CLEANING**

3.19.1. Clean and touch up surfaces of shop-painted equipment scratched or marred during shipment or installation, to match original paint.

3.19.2. Clean and prime exposed non-galvanized hangers, racks and fastenings to prevent rusting.

3.19.3. During the performance of the work and on the completion, remove from the site and premises all debris, rubbish and waste materials caused by the performance of the work for this contract. Remove all tools and surplus materials after completion and acceptance of the work.

3.19.4. Vacuum all equipment thoroughly at the time of final acceptance of the work. Clean plastic components and exposed components of luminaires in accordance with the manufacturer's recommendation.

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PART 1 - GENERAL

1.1. **DESCRIPTION**

1.1.1. This section specifies the furnishing, installation, connection, and testing of the electrical conductors and cables for use in electrical systems rated 600 V and below, indicated as cable(s), conductor(s), wire, or wiring in this section.

1.2. **RELATED WORK**

1.2.1. Section: 26 05 00 Common Work Results for Electrical.

1.2.2. Section: 26 05 26 Grounding and Bonding for Electrical Systems.

1.2.3. Section: 26 05 33 Raceway and Boxes for Electrical Systems.

1.3. **FACTORY TESTS**

1.3.1. Conductors and cables shall be thoroughly tested at the factory per NEMA to ensure that there are no electrical defects. Factory tests shall be certified.

1.4. **SUBMITTALS**

1.4.1. Shop Drawings:

1.4.1.1. Submit sufficient information to demonstrate compliance with drawings and specifications.
1.4.1.2. Submit the following data for approval:
1.4.1.3. Electrical ratings and insulation type for each conductor and cable.
1.4.1.4. Splicing materials and pulling lubricant.

1.4.2. Certifications: Two weeks prior to final inspection, submit the following.

1.4.2.1. Certification by the manufacturer that the conductors and cables conform to the requirements of the drawings and specifications.
1.4.2.2. Certification by the Contractor that the conductors and cables have been properly installed, adjusted, and tested.

1.5. **APPLICABLE PUBLICATIONS**

1.5.1. Publications listed below (including amendments, addenda, revisions, supplements and errata) form a part of this specification to the extent referenced. Publications are reference in the text by designation only.

1.5.1.1. CAN/CSA-C22.2 NO.38-10, Thermoset-Insulated Wire and Cables (Tri-national
1.5.1.2. standard, with UL 44 and ANCE NMX-J-451).
1.5.1.3. CAN/CSA C22.2 NO.51-09, Armored Cables.

1.5.1.4. CAN/CSA C22.2 NO.75-08, Thermoplastic-Insulated Wires and Cables (Trinational
1.5.1.5. standard, with UL 83 and NMX-J-010-ANCE-2008).
1.5.1.6. CAN/CSA C22.2 NO.124-04 (R2009), Mineral-Insulated Cable.
1.5.1.7. CAN/CSA C22.2 NO.131-07, Type TECK 90 Cable.
1.5.1.8. CAN/CSA C22.2 NO. 239-09, Control and Instrumentation Cables.
1.5.1.9. American Society of Testing Material (ASTM):
1.5.1.9.1. D2301-10 Standard Specification for Vinyl Chloride Plastic Pressure-Sensitive Electrical Insulating Tape
1.5.1.9.2. D2304-10 Test Method for Thermal Endurance of Rigid Electrical Insulating Materials
1.5.1.9.3. D3005-10 Low-Temperature Resistant Vinyl Chloride Plastic Pressure-Sensitive Electrical Insulating Tape
1.5.1.10. National Electrical Manufacturers Association (NEMA):
1.5.1.10.1. WC 70-09 Power Cables Rated 2000 Volts or Less for the Distribution of Electrical Energy
1.5.1.11. National Fire Protection Association (NFPA):
1.5.1.11.1. 70-11 National Electrical Code (NEC)
1.5.1.12. Underwriters Laboratories, Inc. (UL):
1.5.1.13. 44-10 Thermoset-Insulated Wires and Cables
1.5.1.14. 83-08 Thermoplastic-Insulated Wires and Cables
1.5.1.15. 467-07 Grounding and Bonding Equipment
1.5.1.16. 486A-486B-03 Wire Connectors
1.5.1.17. 486C-04 Splicing Wire Connectors
1.5.1.18. 486D-05 Sealed Wire Connector Systems
1.5.1.19. 486E-09Equipment Wiring Terminals for Use with Aluminum and/or Copper Conductors
1.5.1.20. 514B-04 Conduit, Tubing, and Cable Fittings

PART 2 - PRODUCTS

2.1. **CONDUCTORS AND CABLES**

2.1.1. Conductors and cables shall be in accordance with NEMA, UL, as specified herein, and as shown on the drawings.

2.1.2. All conductors shall be copper.

2.1.3. Single Conductor and Cable:

2.1.3.1. No. 12 AWG: Minimum size, except where smaller sizes are specified herein or shown on the drawings.
2.1.3.2. No. 8 AWG and larger: Stranded.

2.1.3.3. No. 10 AWG and smaller: Solid; except shall be stranded for final connection to motors, transformers, and vibrating equipment.

2.1.4. Insulation: THHN-THWN and XHHW-2. XHHW-2 shall be used for isolated power systems.

2.2. **SPLICES**

2.2.1. Splices shall be in accordance with NEC and UL.

2.2.2. Above Ground Splices for No. 10 AWG and Smaller:

2.2.2.1. Solderless, screw on, reusable pressure cable type, with integral insulation, approved for copper and aluminum conductors.

2.2.2.2. The integral insulator shall have a skirt to completely cover the stripped conductors.

2.2.2.3. The number, size, and combination of conductors used with the connector, as listed on the manufacturer's packaging, shall be strictly followed.

2.2.3. Above Ground Splices for No. 8 AWG to No. 4/0 AWG:

2.2.3.1. Compression, hex screw, or bolt clamp type of high conductivity and corrosion resistant material, listed for use with copper and aluminum conductors.

2.2.3.2. Insulate with materials approved for the particular use, location, voltage, and temperature. Insulation level shall be not less than the insulation level of the conductors being joined.

2.2.3.3. Splice and insulation shall be product of the same manufacturer.

2.2.3.4. All bolts, nuts, and washers used with splices shall be cadmium-plated.

2.2.4. Above Ground Splices for 250 kcmil and Larger:

2.2.4.1. Long barrel “butt-splice” or “sleeve” type compression connectors, with minimum of two compression indents per wire, listed for use with copper and aluminum conductors.

2.2.4.2. Insulate with materials approved for the particular use, location, voltage, and temperature. Insulation level shall be not less than the insulation level of the conductors being joined.

2.2.4.3. Splice and insulation shall be product of the same manufacturer.

2.3. **CONNECTORS AND TERMINATIONS**

2.3.1. Mechanical type of high conductivity and corrosion resistant material, listed for use with copper and aluminum conductors.

2.3.2. Long barrel compression type of high conductivity and corrosion resistant material, with minimum of two compression indents per wire, listed for use with copper and aluminum conductors.

2.3.3. All bolts, nuts, and washers used to connect connections and terminations to bus bars or other termination points shall be cadmium-plated.

2.4. **CONTROL WIRING**

2.4.1. Unless otherwise specified elsewhere in these specifications, control wiring shall be as specified herein, except that the minimum size shall be not less than No. 14 AWG.

2.4.2. Control wiring shall be sized such that the voltage drop under in-rush conditions does not adversely affect operation of the controls.

2.5. **WIRE LUBRICATING COMPOUND**

2.5.1. Lubricating compound shall be suitable for the wire insulation and conduit, and shall not harden or become adhesive.

2.5.2. Shall not be used on conductors for isolated power systems.

PART 3 - EXECUTION

3.1. **GENERAL**

3.1.1. Install conductors in accordance with the CSEC, NEC, as specified, and as shown on the drawings.

3.1.2. Install all conductors in metallic conduits, unless specified otherwise. Where multiple conduits follow the same routing, provide raceway systems.

3.1.3. Splice conductors only in outlet boxes, junction boxes, pullboxes, manholes, or handholes.

3.1.4. Conductors of different systems (e.g., 120 V and 347 V) shall not be installed in the same raceway.

3.1.5. Install conduit supports for all vertical feeders in accordance with the NEC. Provide split wedge type which firmly clamps each individual cable and tightens due to cable weight.

3.1.6. In panelboards, cabinets, wireways, switches, enclosures, and equipment assemblies, neatly form, train, and tie the conductors with non-metallic ties.

3.1.7. For connections to motors, transformers, and vibrating equipment, stranded conductors shall be used only from the last fixed point of connection to the motors, transformers, or vibrating equipment.

3.1.8. Use expanding foam or non-hardening duct-seal to seal conduits entering a building or where penetrating building walls/floors, after installation of conduits.

3.1.9. Conductor and Cable Pulling:

3.1.9.1. Provide installation equipment that will prevent the cutting or abrasion of insulation during pulling. Use lubricants approved for the cable.

3.1.9.2. Use nonmetallic pull ropes.

3.1.9.3. Attach pull ropes by means of either woven basket grips or pulling eyes attached directly to the conductors.

3.1.9.4. All conductors in a single conduit shall be pulled simultaneously.

3.1.9.5. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.

3.1.9.6. No more than three branch circuits shall be installed in any one conduit.

3.1.9.7. When stripping stranded conductors, use a tool that does not damage the conductor or remove conductor strands.

3.2. **SPLICE AND TERMINATION INSTALLATION**

3.2.1. Splices and terminations shall be mechanically and electrically secure, and tightened to manufacturer's published torque values using a torque screwdriver or wrench.

3.2.2. Where the Consultant determines that unsatisfactory splices or terminations have been installed, replace the splices or terminations at no additional cost to the Board.

3.3. **CONDUCTOR IDENTIFICATION**

3.3.1. When using colored tape to identify phase, neutral, and ground conductors larger than No. 8 AWG, apply tape in half-overlapping turns for a minimum of 75 mm (3 inches) from terminal points, and in junction boxes, pullboxes, and manholes. Apply the last two laps of tape with no tension to prevent possible unwinding. Where cable markings are covered by tape, apply tags to cable, stating size and insulation type.

3.4. **FEEDER CONDUCTOR IDENTIFICATION**

3.4.1. In each interior pullbox, install brass tags on all feeder conductors to clearly designate their circuit identification and voltage. The tags shall be the embossed type, 40 mm (1-1/2 inches) in diameter and 40 mils thick. Attach tags with plastic ties.

3.5. **EXISTING CONDUCTORS**

3.5.1. Unless specifically indicated on the plans, existing conductors shall not be reused.

3.6. **CONTROL WIRING INSTALLATION**

3.6.1. Unless otherwise specified in other sections, install control wiring and connect to equipment to perform the required functions as specified or as shown on the drawings.

3.6.2. Install a separate power supply circuit for each system, except where otherwise shown on the drawings.

3.7. **CONTROL WIRING IDENTIFICATION**

3.7.1. Install a permanent wire marker on each wire at each termination.

3.7.2. Identifying numbers and letters on the wire markers shall correspond to those on the wiring diagrams used for installing the systems.

3.7.3. Wire markers shall retain their markings after cleaning.

3.8. **ACCEPTANCE CHECKS AND TESTS**

3.8.1. Perform in accordance with the manufacturer's recommendations. In addition, include the following:

3.8.1.1. Visual Inspection and Tests: Inspect physical condition.

3.8.2. Electrical tests:

3.8.2.1. After installation but before connection to utilization devices, such as fixtures, motors, or appliances, test conductors' phase-to-phase and phase-to-ground resistance with an insulation resistance tester. Existing conductors to be reused shall also be tested.

3.8.2.2. Applied voltage shall be 500 V DC for 300 V rated cable, and 1000 V DC for 600 V rated cable. Apply test for one minute or until reading is constant for 15 seconds, whichever is longer. Minimum insulation resistance values shall not be less than 25 megohms for 300 V rated cable and 100 megohms for 600 V rated cable.

3.8.2.3. Perform phase rotation test on all three-phase circuits

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PART 1 - GENERAL

1.1. **DESCRIPTION**

1.1.1. This section specifies the furnishing, installation, connection, and testing of grounding and bonding equipment, indicated as grounding equipment in this section.

1.1.2. "Grounding electrode system" refers to grounding electrode conductors and all electrodes required or allowed by CESC and NEC, as well as made, supplementary, and lightning protection system grounding electrodes.

1.1.3. The terms "connect" and "bond" are used interchangeably in this section and have the same meaning.

1.2. **RELATED WORK**

1.2.1. Section: 26 05 00 Common Work Results for Electrical.

1.2.2. Section: 26 05 19 Low-Voltage Electrical Power Conductors and Cables.

1.2.3. Section: 26 05 33 Raceway and Boxes for Electrical Systems.

1.3. **QUALITY ASSURANCE**

1.3.1. Quality Assurance shall be in accordance with Section: 26 05 00 Common Work Results for Electrical.

1.4. **SUBMITTALS**

1.4.1. Submit in accordance with requirements of Section: 26 05 00 Common Work Results for Electrical, and the following requirements:

1.4.1.1. Shop Drawings:

1.4.1.1.1. Submit sufficient information to demonstrate compliance with drawings and specifications.

1.4.1.1.2. Submit plans showing the location of system grounding electrodes and connections, and the routing of aboveground and underground grounding electrode conductors.

1.4.1.2. Test Reports:

1.4.1.2.1. Two weeks prior to the final inspection, submit ground resistance field test reports to the Consultant

1.4.1.3. Certifications:

1.4.1.3.1. Certification by the Contractor that the grounding equipment has been properly installed and tested.

1.5. **APPLICABLE PUBLICATIONS**

1.5.1. Publications listed below (including amendments, addenda, revisions, supplements, and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by designation only.

1.5.2. Canadian Standards Association (CSA)

1.5.2.1. CAN/CSA Standard C22.2 No.0.4-04(R2009) - Bonding of Electrical Equipment.
1.5.2.2. CAN/CSA Standard C22.2 No.41-07 - Grounding and Bonding Equipment (Bi-national standard, with UL 467).
1.5.2.3. Canadian and Ontario Electrical Safety Codes. (Latest Edition).

1.5.3. ANSI/TIA/EIA-607.

1.5.4. (CAN/CSA TS27) Best Practices for Ground and Bonding of Devices in Telecommunication Spaces.

1.5.5. Latest edition of IEEE Standard No. 80.

1.5.6. American Society for Testing and Materials (ASTM):

1.5.6.1. B1-13 Standard Specification for Hard-Drawn Copper Wire
1.5.6.2. B3-13 Standard Specification for Soft or Annealed Copper Wire
1.5.6.3. B8-11 Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft

1.5.7. Institute of Electrical and Electronics Engineers, Inc. (IEEE):

1.5.7.1. 81-12 IEEE Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System Part 1: Normal Measurements

1.5.8. National Fire Protection Association (NFPA):

1.5.8.1. 70-17 National Electrical Code (NEC)
1.5.8.2. 70E-15 National Electrical Safety Code

1.5.9. Underwriters Laboratories, Inc. (UL):

1.5.9.1. 44-14 Thermoset Insulated Wires and Cables
1.5.9.2. 83-14 Thermoplastic Insulated Wires and Cables
1.5.9.3. 467-13 Grounding and Bonding Equipment

PART 2 - PRODUCTS

2.1. **GROUNDING AND BONDING CONDUCTORS**

2.1.1. Install a complete, permanent and continuous system for earthling and grounding of networks, circuits and apparatus. The system shall include electrodes, conductor, connectors and required accessories on drawings to satisfy local authorities.

2.1.2. Install bonding/grounding connections from exposed non-current carrying metal parts of equipment including, but not necessarily limited to the following:

2.1.2.1. Frames of all motors.
2.1.2.2. All Starters.
2.1.2.3. Main Electrical Switchboards.
2.1.2.4. Medium Voltage Load Interrupter Switches.
2.1.2.5. Panelboards and Distribution Panels.
2.1.2.6. Isolations Switch(es).
2.1.2.7. Exterior mounted cable trays.
2.1.2.8. Raised floor pedestals.
2.1.2.9. Conductive Flooring.
2.1.2.10. Communication Rooms.
2.1.2.11. Transformers.
2.1.2.12. Transfer Switches.
2.1.2.13. Power Raceway System.
2.1.2.14. Generating equipment.

2.1.3. Install connectors according to manufacturer's recommendations.

2.1.4. Equipment grounding conductors shall be insulated stranded copper, except that sizes No. 10 AWG and smaller shall be solid copper. Insulation color shall be continuous green for all equipment grounding conductors, except that wire sizes No. 4 AWG and larger shall be identified per NEC.

2.1.5. Bonding conductors shall be bare stranded copper, except that sizes No. 10 AWG and smaller shall be bare solid copper. Bonding conductors shall be stranded for final connection to motors, transformers, and vibrating equipment.

2.1.6. Conductor sizes shall not be less than shown on the drawings, or not less than required by the NEC, whichever is greater.

2.1.7. Insulation: THHN-THWN and XHHW-2. XHHW-2 shall be used for isolated power systems.

2.2. **GROUND RODS**

2.2.1. Copper clad steel, 19 mm (0.75 inch) diameter by 3m (10 feet) long.

2.2.2. Quantity of rods shall be as required to obtain the specified ground resistance.

2.3. **CONCRETE ENCASED ELECTRODE**

2.3.1. Concrete encased electrode shall be No. 4 AWG bare copper wire, installed per NEC.

2.4. **GROUND CONNECTIONS**

2.4.1. Below Grade and Inaccessible Locations: Exothermic-welded type connectors.

2.4.2. Above Grade:

2.4.2.1. Bonding Jumpers: Listed for use with copper conductors. For wire sizes No. 8 AWG and larger, use compression-type connectors. For wire sizes smaller than No. 8 AWG, use mechanical type lugs. Connectors or lugs shall use zinc-plated steel bolts, nuts, and washers. Bolts shall be torqued to the values recommended by the manufacturer.

2.4.2.2. Connection to Building Steel: Exothermic-welded type connectors.

2.4.2.3. Connection to Grounding Bus Bars: Listed for use with aluminum and copper conductors. Use mechanical type lugs, with zinc-plated steel bolts, nuts, and washers. Bolts shall be torqued to the values recommended by the manufacturer.

2.4.2.4. Connection to Equipment Rack and Cabinet Ground Bars: Listed for use with aluminum and copper conductors. Use mechanical type lugs, with zinc-plated steel bolts, nuts, and washers. Bolts shall be torqued to the values recommended by the manufacturer.

2.5. **EQUIPMENT RACK AND CABINET GROUND BARS**

2.5.1. Provide solid copper ground bars designed for mounting on the framework of open or cabinet-enclosed equipment racks. Ground bars shall have minimum dimensions of 6.3 mm (0.25 inch) thick x 19 mm (0.75 inch) wide, with length as required or as shown on the drawings. Provide insulators and mounting brackets.

2.6. **GROUND TERMINAL BLOCKS**

2.6.1. At any equipment mounting location (e.g., backboards and hinged cover enclosures) where rack-type ground bars cannot be mounted, provide mechanical type lugs, with zinc-plated steel bolts, nuts, and washers. Bolts shall be torqued to the values recommended by the manufacturer.

2.7. **GROUNDING BUS BAR**

2.7.1. Pre-drilled rectangular copper bar with stand-off insulators, minimum 6.3 mm (0.25 inch) thick x100 mm (4 inches) high in cross-section, length as shown on the drawings, with hole size, quantity, and spacing per detail shown on the drawings. Provide insulators and mounting brackets.

PART 3 - EXECUTION

3.1. **GENERAL**

3.1.1. Installation shall be in accordance with the CEC, NEC, and manufacturer's instructions.

3.1.2. System Grounding:

3.1.2.1. Secondary service neutrals: Ground at the supply side of the secondary disconnecting means and at the related transformer.

3.1.2.2. Separately derived systems (transformers downstream from the service entrance): Ground the secondary neutral.

3.1.2.3. Equipment Grounding: Metallic piping, building structural steel, electrical enclosures, raceways, junction boxes, outlet boxes, cabinets, machine frames, and other conductive items in close proximity with electrical circuits, shall be bonded and grounded.

3.2. **INACCESSIBLE GROUNDING CONNECTIONS**

3.2.1. Make grounding connections, which are normally buried or otherwise inaccessible, by exothermic weld.

3.3. **SECONDARY VOLTAGE EQUIPMENT AND CIRCUITS**

3.3.1. Main Bonding Jumper: Bond the secondary service neutral to the ground bus in the service equipment.

3.3.2. Metallic Piping, Building Structural Steel, and Supplemental Electrode(s):

3.3.2.1. Provide a grounding electrode conductor sized per CESC and NEC between the service equipment ground bus and all metallic water pipe systems, building structural steel, and supplemental or made electrodes. Provide jumpers across insulating joints in the metallic piping.

3.3.2.2. Provide a supplemental ground electrode to bond to the grounding electrode system.

3.3.3. Switchgear, Switchboards, Unit Substations, Panelboards, Motor Control Centers, Engine-Generators, Automatic Transfer Switches, and other electrical equipment:

3.3.3.1. Connect the equipment grounding conductors to the ground bus.

3.3.3.2. Connect metallic conduits by grounding bushings and equipment grounding conductor to the equipment ground bus.

3.3.4. Transformers:

3.3.4.1. Exterior: Exterior transformers supplying interior service equipment shall have the neutral grounded at the transformer secondary. Provide a grounding electrode at the transformer.

3.3.4.2. Separately derived systems (transformers downstream from service equipment): Ground the secondary neutral at the transformer. Provide a grounding electrode conductor from the transformer to the nearest suitable component of the grounding electrode system.

3.4. **RACEWAY**

3.4.1. Conduit Systems:

3.4.1.1. Ground all metallic conduit systems. All metallic conduit systems shall contain an equipment grounding conductor.

3.4.1.2. Nonmetallic conduit systems, except non-metallic feeder conduits that carry a grounded conductor from exterior transformers to interior or building-mounted service entrance equipment, shall contain an equipment grounding conductor.

3.4.1.3. Metallic conduit that only contains a grounding conductor, and is provided for its mechanical protection, shall be bonded to that conductor at the entrance and exit from the conduit.

3.4.1.4. Metallic conduits which terminate without mechanical connection to an electrical equipment housing by means of locknut and bushings or adapters, shall be provided with grounding bushings. Connect bushings with a equipment grounding conductor to the equipment ground bus.

3.4.2. Feeders and Branch Circuits: Install equipment grounding conductors with all feeders, and power and lighting branch circuits.

3.4.3. Boxes, Cabinets, Enclosures, and Panelboards:

3.4.3.1. Bond the equipment grounding conductor to each pullbox, junction box, outlet box, device box, cabinets, and other enclosures through which the conductor passes (except for special grounding systems for intensive care units and other critical units shown).

3.4.3.2. Provide lugs in each box and enclosure for equipment grounding conductor termination.

3.4.4. Wireway Systems:

3.4.4.1. Bond the metallic structures of wireway to provide electrical continuity throughout the wireway system, by connecting a No. 6 AWG bonding jumper at all intermediate metallic enclosures and across all section junctions.

3.4.4.2. Install insulated No. 6 AWG bonding jumpers between the wireway system, bonded as required above, and the closest building ground at each end and approximately every 16 M (50 feet).

3.4.4.3. Use insulated No. 6 AWG bonding jumpers to ground or bond metallic wireway at each end for all intermediate metallic enclosures and across all section junctions.

3.4.4.4. Use insulated No. 6 AWG bonding jumpers to ground cable tray to column-mounted building ground plates (pads) at each end and approximately every 15 M (49 feet).

3.4.4.5. Receptacles shall not be grounded through their mounting screws. Ground receptacles with a jumper from the receptacle green ground terminal to the device box ground screw and a jumper to the branch circuit equipment grounding conductor.

3.4.5. Ground lighting fixtures to the equipment grounding conductor of the wiring system. Fixtures connected with flexible conduit shall have a green ground wire included with the power wires from the fixture through the flexible conduit to the first outlet box.

3.4.6. Fixed electrical appliances and equipment shall be provided with a ground lug for termination of the equipment grounding conductor.

3.5. OUTDOOR METALLIC FENCES AROUND ELECTRICAL EQUIPMENT

3.5.1. Fences shall be grounded with a ground rod at each fixed gate post and at each corner post.

3.5.2. Drive ground rods until the top is 300 mm (12 inches) below grade. Attach a No. 4 AWG copper conductor by exothermic weld to the ground rods, and extend underground to the immediate vicinity of fence post. Lace the conductor vertically into 300 mm (12 inches) of fence mesh and fasten by two approved bronze compression fittings, one to bond the wire to post and the other to bond the wire to fence. Each gate section shall be bonded to its gatepost by a 3 mm x 25 mm (0.375 inch x 1 inch) flexible, braided copper strap and ground post clamps. Clamps shall be of the anti-electrolysis type.

3.6. CORROSION INHIBITORS

3.6.1. When making grounding and bonding connections, apply a corrosion inhibitor to all contact surfaces. Use corrosion inhibitor appropriate for protecting a connection between the metals used.

3.7. CONDUCTIVE PIPING

3.7.1. Bond all conductive piping systems, interior and exterior, to the grounding electrode system. Bonding connections shall be made as close as practical to the equipment ground bus.

3.7.2. In operating rooms and at intensive care and coronary care type beds, bond the medical gas piping and medical vacuum piping at the outlets directly to the patient ground bus.

3.8. **MAIN ELECTRICAL ROOM GROUNDING**

3.8.1. Provide ground bus bar and mounting hardware at each main electrical room where incoming feeders are terminated, as shown on the drawings. Connect to pigtail extensions of the building grounding ring, as shown on the drawings.

3.9. **GROUND RESISTANCE**

3.9.1. Grounding system resistance to ground shall not exceed 5 ohms. Make any modifications or additions to the grounding electrode system necessary for compliance without additional cost to the Government. Final tests shall ensure that this requirement is met.

3.9.2. Grounding system resistance shall comply with the electric utility company ground resistance requirements.

3.10. **GROUND ROD INSTALLATION**

3.10.1. For outdoor installations, drive each rod vertically in the earth, until top of rod is 610 mm (24 inches) below final grade.

3.10.2. For indoor installations, leave 100 mm (4 inches) of each rod exposed.

3.10.3. Where buried or permanently concealed ground connections are required, make the connections by the exothermic process, to form solid metal joints. Make accessible ground connections with mechanical pressure-type ground connectors.

3.10.4. Where rock or impenetrable soil prevents the driving of vertical ground rods, install angled ground rods or grounding electrodes in horizontal trenches to achieve the specified ground resistance.

3.11. **ACCEPTANCE CHECKS AND TESTS**

3.11.1. Resistance of the grounding electrode system shall be measured using a four-terminal fall-of-potential method as defined in IEEE 81. Ground resistance measurements shall be made before the electrical distribution system is energized or connected to the electric utility company ground system, and shall be made in normally dry conditions not fewer than 48 hours after the last rainfall.

3.11.2. Resistance measurements of separate grounding electrode systems shall be made before the systems are bonded together. The combined resistance of separate systems may be used to meet the required resistance, but the specified number of electrodes must still be provided.

3.11.3. Below-grade connections shall be visually inspected by the Consultant prior to backfilling. The Contractor shall notify the Consultant 24 hours before the connections are ready for inspection

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PART 1 - GENERAL

1.1. **DESCRIPTION**

1.1.1. This section specifies the furnishing, installation, and connection of conduit, fittings, and boxes, to form complete, coordinated, grounded raceway systems. Raceways are required for all wiring unless shown or specified otherwise.

1.1.2. Definitions: The term conduit, as used in this specification, shall mean any or all of the raceway types specified.

1.2. **RELATED WORK**

1.2.1. Section: 26 05 00 Common Work Results for Electrical.

1.3. **QUALITY ASSURANCE**

1.3.1. Refer to Paragraph, QUALIFICATIONS, in Section: 26 05 00 Common Work Results for Electrical.

1.4. **SUBMITTALS**

1.4.1. Submit in accordance with Section: 26 05 00 Common Work Results for Electrical.

1.4.2. Shop Drawings:

1.4.2.1. Size and location of main feeders.
1.4.2.2. Size and location of panels and pull-boxes.
1.4.2.3. Layout of required conduit penetrations through structural elements.
1.4.2.4. Submit the following data for approval:
1.4.2.5. Raceway types and sizes.
1.4.2.6. Conduit bodies, connectors and fittings.
1.4.2.7. Splitter troughs
1.4.2.8. Junction and pull boxes, types and sizes.

1.4.3. Certifications: Two weeks prior to final inspection, submit the following:

1.4.3.1. Certification by the manufacturer that raceways, conduits, conduit bodies, connectors, fittings, junction and pull boxes, and all related equipment conform to the requirements of the drawings and specifications.
1.4.3.2. Certification by the Contractor that raceway, conduits, conduit bodies, connectors, fittings, junction and pull boxes, and all related equipment have been properly installed.

1.5. **APPLICABLE PUBLICATIONS**

1.5.1. Publications listed below (including amendments, addenda, revisions, supplements, and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by designation only.

1.5.2. Canadian Standards Association (CSA International)

1.5.2.1. CAN/CSA C22.2 No. 18.3-12, Conduit, Tubing, and Cable Fittings (Tri-National standard, with ANCE NMX-J-017 and UL 514B).
1.5.2.2. CAN/CSA C22.2 No. 18.4-04 (R2009), Hardware for the Support of Conduit, Tubing, and Cable (Bi-National standard, with UL 2239).
1.5.2.3. CAN/CSA C22.2 No. 18.5-02 (R2012), Positioning Devices (Bi-National standard, with UL 1565).
1.5.2.4. C22.2 NO.45.1-07, Electrical Rigid Metal Conduit – Steel (Tri-national standard, with UL 6 and NMX-J-534-ANCE-2007).
1.5.2.5. C22.2 No.56-04 (R2009) Flexible Metal Conduit and Liquid-Tight Flexible Metal Conduit.
1.5.2.6. C22.2 NO.83-M1985 (R2008), Electrical Metallic Tubing.
1.5.2.7. C22.2 No.211.2-06 (R2011) Rigid PVC (Unplasticized) Conduit.
1.5.2.8. CAN/CSA C22.2 NO.227.1-06 (R2011), Electrical Nonmetallic Tubing (Bi-National standard, with UL 1653).
1.5.2.9. CAN/CSA C22.2 NO.227.2.1-04 (R2009), Liquid-Tight Flexible Nonmetallic Conduit (Bi-National standard, with UL 1660).
1.5.2.10. CAN/CSA C22.2 No. 227.3-05 (R2010), Nonmetallic Mechanical Protection Tubing (NMPT), (Bi-national standard, with UL 1696).

1.5.3. American National Standards Institute (ANSI):

1.5.3.1. C80.1-05 Electrical Rigid Steel Conduit
1.5.3.2. C80.3-05 Steel Electrical Metal Tubing
1.5.3.3. C80.6-05 Electrical Intermediate Metal Conduit

1.5.4. National Fire Protection Association (NFPA):

1.5.5. 70-11 National Electrical Code (NEC)

1.5.6. Underwriters Laboratories, Inc. (UL):

1.5.6.1. 1-05 Flexible Metal Conduit
1.5.6.2. 5-11 Surface Metal Raceway and Fittings
1.5.6.3. 6-07 Electrical Rigid Metal Conduit - Steel
1.5.6.4. 50-95 Enclosures for Electrical Equipment
1.5.6.5. 360-13 Liquid-Tight Flexible Steel Conduit
1.5.6.6. 467-13 Grounding and Bonding Equipment
1.5.6.7. 514A-13 Metallic Outlet Boxes

1.5.6.8.	514B-12	Conduit, Tubing, and Cable Fittings
1.5.6.9.	514C-07	Nonmetallic Outlet Boxes, Flush-Device Boxes and Covers
1.5.6.10.	797-07	Electrical Metallic Tubing
1.5.6.11.	1242-06	Electrical Intermediate Metal Conduit - Steel

1.5.7. National Electrical Manufacturers Association (NEMA):

1.5.7.1. FB1-12 Fittings, Cast Metal Boxes and Conduit Bodies for Conduit, Electrical Metallic Tubing and Cable

1.5.7.2. FB2.10-13 Selection and Installation Guidelines for Fittings for use with Non-Flexible Conduit or Tubing (Rigid Metal Conduit, Intermediate Metallic Conduit, and Electrical Metallic Tubing)

1.5.7.3. FB2.20-12 Selection and Installation Guidelines for Fittings for use with Flexible Electrical Conduit and Cable

PART 2 - PRODUCTS

2.1. **MATERIAL**

2.1.1. Conduit Size: In accordance with the CEC/NFPA-70, but not less than 13 mm (0.5-inch) unless otherwise shown.

2.1.2. Rigid Steel Conduit (RMC): Shall conform to CAN/CSA C22.2 NO.45.1, UL 6 and ANSI C80.1. *Application: for all outdoor installations and other locations where specified or shown on the drawings*.

2.1.3. Rigid Intermediate Steel Conduit (IMC): Shall conform to CAN/CSA C22.2 NO.18.3, UL 1242 and ANSI C80.6. *Application: for all outdoor installations and other locations where specified or shown on the drawings.*

2.1.4. Electrical Metallic Tubing (EMT): Shall conform to CAN/CSA C22.2 NO.83, UL 797 and ANSI C80.3. Maximum size not to exceed 105 mm (4 inches) and shall be permitted only with cable rated 600 V or less. *Application: for all indoor installations and other locations where specified or shown on the drawings.*

2.1.5. Flexible Metal Conduit: Shall conform to CAN/CSA C22.2 NO.56, UL 1. *Application: last 1000 mm (40") before final connections to burners and other locations where specified or shown on the drawings*.

2.1.6. Liquid-tight Flexible Metal Conduit: Shall conform to CAN/CSA C22.2 NO.227.2.1, UL 360. *Applications: last 1000 mm (40") before connecting to motors and other vibrating equipment and other locations where specified or shown on the drawings*.

2.2. **CONDUIT FITTINGS**

2.2.1. Rigid Steel and Intermediate Metallic Conduit Fittings:

2.2.1.1. Fittings shall meet the requirements of UL 514B and NEMA FB1.

2.2.1.2. Standard threaded couplings, locknuts, bushings, conduit bodies, and elbows: Only steel or malleable iron materials are acceptable. Integral retractable type IMC couplings are also acceptable.

2.2.1.3. Locknuts: Bonding type with sharp edges for digging into the metal wall of an enclosure.

2.2.1.4. Bushings: Metallic insulating type, consisting of an insulating insert, molded or locked into the metallic body of the fitting. Bushings made entirely of metal or nonmetallic material are not permitted.

2.2.1.5. Erickson (Union Type) and Set Screw Type Couplings: Approved for use in concrete is permitted for use to complete a conduit run where conduit is installed in concrete. Use set screws of case-hardened steel with hex head and cup point to firmly seat in conduit wall for positive ground. Tightening of set screws with pliers is prohibited.

2.2.1.6. Sealing Fittings: Threaded cast iron type. Use continuous drain-type sealing fittings to prevent passage of water vapor. In concealed work, install fittings in flush steel boxes with blank cover plates having the same finishes as that of other electrical plates in the room.

2.2.2. Electrical Metallic Tubing Fittings:

2.2.2.1. Fittings and conduit bodies shall meet the requirements of UL 514B, ANSI C80.3, and NEMA FB1.

2.2.2.2. Only steel or malleable iron materials are acceptable.

2.2.2.3. Both compression and setscrew fittings are allowed, but one choice is to be made for a project. Fittings are to be of uniform type throughout the project.

2.2.2.4. Compression Couplings and Connectors: Concrete-tight and rain-tight, with connectors having insulated throats.

2.2.2.5. Setscrew Couplings and Connectors: Use setscrews of case-hardened steel with hex head and cup point, to firmly seat in wall of conduit for positive grounding

2.2.2.6. Indent-type connectors or couplings are prohibited.

2.2.2.7. Die-cast or pressure-cast zinc-alloy fittings or fittings made of "pot metal" are prohibited.

2.2.3. Flexible Metal Conduit Fittings:

2.2.3.1. Conform to UL 514B. Only steel or malleable iron materials are acceptable.

2.2.3.2. Clamp-type, with insulated throat.

2.2.3.3. Liquid tight Flexible Metal Conduit Fittings:

2.2.3.4. Fittings shall meet the requirements of UL 514B and NEMA FB1.

2.2.3.5. Only steel or malleable iron materials are acceptable.

2.2.3.6. Fittings must incorporate a threaded grounding cone, a steel or plastic compression ring, and a gland for tightening. Connectors shall have insulated throats.

2.2.4. Surface Metal Raceway Fittings:

2.2.4.1. As recommended by the raceway manufacturer. Include couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, conduit entry fittings, accessories, and other fittings as required for complete system.

2.2.5. Expansion and Deflection Couplings:

2.2.5.1. Conform to UL 467 and UL 514B.

2.2.5.2. Accommodate a 19 mm (0.75-inch) deflection, expansion, or contraction in any direction, and allow 30 degree angular deflections.

2.2.5.3. Include internal flexible metal braid, sized to guarantee conduit ground continuity and a low-impedance path for fault currents, in accordance with UL 467 and the CEC tables for equipment grounding conductors.

2.2.6. Jacket: Flexible, corrosion resistant, watertight, moisture and heat-resistant molded rubber material with stainless steel jacket clamps.

2.2.7. Conduit Supports:

2.2.7.1. Parts and Hardware: Zinc coat or provide equivalent corrosion protection.

2.2.7.2. Individual Conduit Hangers: Designed for the purpose, having a pre assembled closure bolt and nut, and provisions for receiving a hanger rod.

2.2.7.3. Multiple Conduit (Trapeze) Hangers: Not less than 38 mm x 38 mm (1.5 x 1.5 inches), 12-gauge steel, cold-formed, lipped channels; with not less than 9 mm (0.375-inch) diameter steel hanger rods.

2.2.7.4. Solid Masonry and Concrete Anchors: Self drilling expansion shields, or machine bolt expansion.

2.2.8. Outlet, Junction, and Pull Boxes:

2.2.8.1. Applicable Publications

2.2.8.1.1. CAN/CSA C22.2 NO.18.1-04 (R2009), Metallic Outlet Boxes (Tri-National standard with ANCE NMX-J-023/1 and UL 514A).

2.2.8.1.2. C22.2 NO.18.2-06, Nonmetallic Outlet Boxes.

2.2.8.1.3. CAN/CSA C22.2 NO.18.3-12, Conduit, Tubing and Cable Fittings (Tri-national standard, with ANCE NMX-J-017 and UL 514B).

2.2.8.1.4. UL-50 and UL-514A.

2.2.8.2. Rustproof cast metal where required by the NEC or shown on drawings.

2.2.8.3. Sheet Metal Boxes: Galvanized steel, except where shown on drawings.

2.2.9. Metal Wireways: Equip with hinged covers, except as shown on drawings. Include couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for a complete system.

2.2.10. Splitter troughs

2.2.10.1. Sheet metal enclosure with welded edges and hinged shaped cover with locking facility when closed.

2.2.10.2. Copper bus bars c/w terminals corresponding to the number and size of the incoming and outgoing conductors as shown.

2.2.10.3. Unless otherwise indicated the splitters shall have sufficient length to accommodate the layout of the secondary equipment.

2.2.10.4. Supply at least three space terminals for each terminal size in 400 A and less splitters.

PART 3 - EXECUTION

3.1. **PENETRATIONS**

3.1.1. Cutting or Holes:

3.1.1.1. Cut holes in advance where they should be placed in the structural elements, such as ribs or beams.

3.1.1.2. Cut holes through concrete and masonry in new and existing structures with a diamond core drill or concrete saw.

3.1.1.3. Firestop: Where conduits, wireways, and other electrical raceways pass through fire partitions, fire walls, smoke partitions, or floors, install a fire stop that provides an effective barrier against the spread of fire, smoke and gases.

3.1.1.4. Verify that roof penetration details are shown on drawings.

3.1.1.5. Waterproofing: At floor, exterior wall, and roof conduit penetrations, completely seal the gap around conduit to render it watertight.

3.2. **INSTALLATION, GENERAL**

3.2.1. In accordance with ULC, OESC, CEC, NEC, NEMA, as shown on drawings, and as specified herein.

3.2.2. Raceway systems used for Essential Electrical Systems (EES) shall be entirely independent of other raceway systems.

3.2.3. Install conduit as follows:

3.2.3.1. In fully completed mechanically and electrically continuous runs before pulling in cables or wires.

3.2.3.2. Unless otherwise indicated on the drawings or specified herein, installation of all conduits shall be concealed within finished walls, floors, and ceilings.

3.2.3.3. Flattened, dented, or deformed conduit is not permitted. Remove and replace the damaged conduits with new conduits.

3.2.3.4. Assure conduit installation does not encroach into the ceiling height head room, walkways, or doorways.

3.2.3.5. Cut conduits square, ream, remove burrs, and draw up tight.

3.2.3.6. Independently support conduit at 2.4 M (8 feet) on centers with specified materials or as shown on drawings.

3.2.3.7. Do not use suspended ceilings, suspended ceiling supporting members, lighting fixtures, other conduits, cable tray, boxes, piping, or ducts to support conduits and conduit runs.

3.2.3.8. Support within 300 mm (12 inches) of changes of direction, and within 300 mm (12 inches) of each enclosure to which connected.

3.2.3.9. Close ends of empty conduits with plugs or caps at the rough in stage until wires are pulled in, to prevent entry of debris.

3.2.3.10. Conduit installations under fume and vent hoods are prohibited.

3.2.3.11. Secure conduits to cabinets, junction boxes, pull-boxes, and outlet boxes with bonding type locknuts. For rigid steel and IMC conduit installations, provide a locknut on the inside of the enclosure, made up wrench tight. Do not make conduit connections to junction box covers.

3.2.3.12. Flashing of penetrations of the roof membrane is shown on the drawing details.

3.2.3.13. Conduit bodies shall only be used for changes in direction, and shall not contain splices.

3.2.4. Conduit Bends:

3.2.4.1. Make bends with standard conduit bending machines.

3.2.4.2. Conduit hickey may be used for slight offsets and for straightening stubbed out conduits.

3.2.4.3. Bending of conduits with a pipe tee or vise is prohibited.

3.2.5. Layout and Homeruns:

3.2.5.1. Install conduit with wiring, including homeruns, as shown on drawings.

3.2.5.2. Deviations: Make only where necessary to avoid interferences.

3.3. **CONCEALED WORK INSTALLATION**

3.3.1. In Concrete:

3.3.1.1. Conduit: Rigid steel, IMC, or EMT. Do not install EMT in concrete slabs that are in contact with soil, gravel, or vapor barriers.

3.3.1.2. Align and run conduit in direct lines.

3.3.1.3. Install conduit through concrete beams only:

3.3.1.4. Where shown on the structural drawings.

3.3.1.5. Installation of conduit in concrete that is less than 75 mm (3 inches) thick is prohibited.

3.3.1.6. Conduit outside diameter larger than one-third of the slab thickness is prohibited.

3.3.1.7. Space between conduits in slabs: Approximately six conduit diameters apart, and one conduit diameter at conduit crossings.

3.3.1.8. Install conduits approximately in the center of the slab so that there will be a minimum of 19 mm (0.75-inch) of concrete around the conduits.

3.3.1.9. Make couplings and connections watertight. Use thread compounds that are UL approved conductive type to ensure low resistance ground continuity through the conduits. Tightening setscrews with pliers is prohibited.

3.3.2. Above Furred or Suspended Ceilings and in Walls:

3.3.2.1. Conduit for Conductors 600 V and Below: EMT.

3.3.2.2. Align and run conduit parallel or perpendicular to the building lines.

3.3.2.3. Connect recessed lighting fixtures to conduit runs with maximum 1.8 M (6 feet) of flexible metal conduit extending from a junction box to the fixture.

3.3.2.4. Tightening set screws with pliers is prohibited.

3.3.2.5. For conduits running through metal studs, limit field cut holes to no more than 70% of web depth. Spacing between holes shall be at least 457 mm (18 inches). Cuts or notches in flanges or return lips shall not be permitted.

3.4. **EXPOSED WORK INSTALLATION**

3.4.1. Unless otherwise indicated on drawings, exposed conduit is only permitted in mechanical and electrical rooms.

3.4.2. Conduit for Conductors 600 V and Below: Rigid steel or IMC (outdoors), EMT (indoors). Mixing different types of conduits in the system is prohibited.

3.4.3. Align and run conduit parallel or perpendicular to the building lines.

3.4.4. Install horizontal runs close to the ceiling or beams and secure with conduit straps.

3.4.5. Support horizontal or vertical runs at not over 2.4 M (8 feet) intervals.

3.4.6. Surface Metal Raceways: Use only where shown on drawings.

3.4.7. Painting:

3.4.7.1. Paint exposed conduit as specified

3.5. **HAZARDOUS LOCATIONS**

3.5.1. Use rigid steel conduit only.

3.5.2. Install UL approved sealing fittings that prevent passage of explosive vapors in hazardous areas equipped with explosion-proof lighting fixtures, switches, and receptacles, as required by the NEC.

3.6. **WET OR DAMP LOCATIONS**

3.6.1. Use rigid steel or IMC conduits unless as shown on drawings.

3.6.2. Provide sealing fittings to prevent passage of water vapor where conduits pass from warm to cold locations, i.e., refrigerated spaces, constant-temperature rooms, air-conditioned spaces, building exterior walls, roofs, or similar spaces.

3.6.3. Use rigid steel or IMC conduit within 1.5 M (5 feet) of the exterior and below concrete building slabs in contact with soil, gravel, or vapor barriers, unless as shown on drawings. Conduit shall be half-lapped with 10 mil PVC tape before installation. After installation, completely recoat or retape any damaged areas of coating.

3.6.4. Conduits run on roof shall be supported with integral galvanized lipped steel channel, attached to UV-inhibited polycarbonate or polypropylene blocks every 2.4 M (8 feet) with 9 mm (3/8-inch) galvanized threaded rods, square washer and locknut. Conduits shall be attached to steel channel with conduit clamps.

3.7. **MOTORS AND VIBRATING EQUIPMENT**

3.7.1. Use flexible metal conduit for connections to motors and other electrical equipment subject to movement, vibration, misalignment, cramped quarters, or noise transmission.

3.7.2. Use liquid tight flexible metal conduit for installation in exterior locations, moisture or humidity laden atmosphere, corrosive atmosphere, water or spray wash down operations, inside airstream of HVAC units, and locations subject to seepage or dripping of oil, grease, or water.

3.7.3. Provide a green equipment grounding conductor with flexible and liquid-tight flexible metal conduit.

3.8. **EXPANSION JOINTS**

3.8.1. Conduits 75 mm (3 inch) and larger that are secured to the building structure on opposite sides of a building expansion joint require expansion and deflection couplings. Install the couplings in accordance with the manufacturer's recommendations.

3.8.2. Provide conduits smaller than 75 mm (3 inch) with junction boxes on both sides of the expansion joint. Connect flexible metal conduits to junction boxes with sufficient slack to produce a 125 mm (5 inch) vertical drop midway between the ends of the flexible metal conduit. Flexible metal conduit shall have a green insulated copper bonding jumper installed. In lieu of this flexible metal conduit, expansion and deflection couplings as specified above are acceptable.

3.8.3. Install expansion and deflection couplings where shown.

3.9. **CONDUIT SUPPORTS**

3.9.1. Safe working load shall not exceed one-quarter of proof test load of fastening devices.

3.9.2. Use pipe straps or individual conduit hangers for supporting individual conduits.

3.9.3. Support multiple conduit runs with trapeze hangers. Use trapeze hangers that are designed to support a load equal to or greater than the sum of the weights of the conduits, wires, hanger itself, and an additional 90 kg (200 lbs). Attach each conduit with U bolts or other approved fasteners.

3.9.4. Support conduit independently of junction boxes, pull-boxes, fixtures, suspended ceiling T bars, angle supports, and similar items.

3.9.5. Fasteners and Supports in Solid Masonry and Concrete:

3.9.5.1. New Construction: Use steel or malleable iron concrete inserts set in place prior to placing the concrete.

3.9.6. Existing Construction:

3.9.6.1. Steel expansion anchors not less than 6 mm (0.25-inch) bolt size and not less than 28 mm (1.125 inch) in embedment.

3.9.6.2. Power set fasteners not less than 6 mm (0.25-inch) diameter with depth of penetration not less than 75 mm (3 inch).

3.9.6.3. Use vibration and shock-resistant anchors and fasteners for attaching to concrete ceilings.

3.9.6.4. Hollow Masonry: Toggle bolts.

3.9.6.5. Bolts supported only by plaster or gypsum wallboard are not acceptable.

3.9.6.6. Metal Structures: Use machine screw fasteners or other devices specifically designed and approved for the application.

3.9.6.7. Attachment by wood plugs, raw plug, plastic, lead or soft metal anchors, or wood blocking and bolts supported only by plaster is prohibited.

3.9.6.8. Chain, wire, or perforated strap shall not be used to support or fasten conduit.

3.9.6.9. Spring steel type supports or fasteners are prohibited for all uses except horizontal and vertical supports/fasteners within walls.

3.9.6.10. Vertical Supports: Vertical conduit runs shall have riser clamps and supports in accordance with the NEC and as shown. Provide supports for cable and wire with fittings that include internal wedges and retaining collars.

3.10. **BOX INSTALLATION**

3.10.1. Boxes for Concealed Conduits:

3.10.1.1. Flush-mounted.

3.10.1.1.1. Provide raised covers for boxes to suit the wall or ceiling, construction, and finish.

3.10.1.1.2. In addition to boxes shown, install additional boxes where needed to prevent damage to cables and wires during pulling-in operations or where more than the equivalent of 4-90 degree bends are necessary.

3.10.1.1.3. Locate pullboxes so that covers are accessible and easily removed. Coordinate locations with piping and ductwork where installed above ceilings.

3.10.1.1.4. Remove only knockouts as required. Plug unused openings. Use threaded plugs for cast metal boxes and snap in metal covers for sheet metal boxes.

3.10.1.1.5. Outlet boxes mounted back to back in the same wall are prohibited. A minimum 600 mm (24 inch) center-to-center lateral spacing shall be maintained between boxes.

3.10.1.2. Flush-mounted wall or ceiling boxes shall be installed with raised covers so that the front face of raised cover is flush with the wall. Surface-mounted wall or ceiling boxes shall be installed with surface-style flat or raised covers.

3.10.1.3. Minimum size of outlet boxes for ground fault circuit interrupter (GFCI) receptacles is 100 mm (4 inches) square x 55 mm (2.125 inches) deep, with device covers for the wall material and thickness involved.

3.10.1.4. Stencil or install phenolic nameplates on covers of the boxes identified on riser diagrams; for example "SIG FA JB No. 1."

3.10.1.5. On all branch circuit junction box covers, identify the circuits with black marker.

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PART 1 - GENERAL

1.1. **RELATED SECTIONS**

1.1.1. Section: 26 24 16.01 Panelboards Breaker Type.

1.2. **REFERENCES**

1.2.1. CAN/CSA-C22.2 No. 5-09, Moulded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures (Tri-national standard, with UL 489 and NMX-J-266-ANCE-2010).

1.2.2. AN/CSA-C22.2 No. 144-M91 (R2011): Ground Fault Circuit Interrupters.

1.2.3. CAN/CSA-C22.2 No. 144.1- 06 (R2011): Ground-Fault Circuit-Interrupters (Tri-National standard, with UL 943 and NMX-J-520-ANCE).

1.3. **SUBMITTALS**

1.3.1. Submit product data in accordance with Section: 01 33 23 Shop Drawings, Product Data, and Samples.

1.3.2. Include time-current characteristic curves for breakers with ampacity of 200A and over or with interrupting capacity of 22,000A symmetrical (rms) and over at system voltage.

1.3.3. Acceptable Materials

1.3.3.1. Schneider Electric Canada;
1.3.3.2. Siemens Canada;
1.3.3.3. Eaton Electric.

PART 2 - PRODUCTS

2.1. **BREAKERS GENERAL**

2.1.1. Molded case circuit breakers and Ground-fault circuit interrupters: to C22.2 NO. 5.

2.1.2. Comply with UL 489, NEMA AB 1, and NEMA AB 3, fully rated with interrupting capacity to comply with available fault currents.

2.1.3. Bolt-on moulded case circuit breakers: quick-make, quick-break type, for manual and automatic operation with temperature compensation for 40 degrees C ambient.

2.1.4. Common-trip breakers: with single handle for multi-pole applications.

2.1.5. Magnetic instantaneous trip elements in circuit breakers to operate only when the value of the current reaches the setting.

2.1.6. Trip settings on breakers with adjustable trips to range of 3 to 8 times the rated current.

2.1.7. Provide pad locking devices where indicated on breakers to lock the handle of a breaker in the "on" or "off" position with the trip units to remain free to function and protect the circuit from both overload and short circuit conditions.

2.2. **GENERAL REQUIREMENTS**

2.2.1. Circuit breakers 250 Amps and larger shall be rated to carry 100% of their current rating continuously.

2.2.2. Thermal-Magnetic Circuit Breakers:

2.2.2.1. Molded case circuit 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.

2.2.2.2. Inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A up to 400 A.

2.2.2.3. Adjustable, Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.

2.2.3. Solid State Trip Breakers (LSI)

2.2.3.1. Moulded case circuit breakers to operate by means of solid-state trip unit with associated current monitors and self-powered shunt trip to provide inverse time current trip under overload condition, and long time, short time, instantaneous tripping for circuit protection.

2.2.3.2. Electronic Trip Circuit Breakers: 400 A and larger. Field-replaceable rating plug, rms sensing, with the following field-adjustable settings:

2.2.3.3. Instantaneous trip.

2.2.3.4. Long- and short-time pickup levels.

2.2.3.5. Long- and short-time time adjustments.

2.2.3.6. Ground-fault pickup level, time delay, and I^2t response

2.2.4. Each adjustment shall have discrete settings (fully adjustable) and shall be independent of all other adjustments.

2.2.5. Long Time Pickup indication to signal when loading approaches or exceeds the adjustable ampere rating of the circuit breaker shall be provided.

PART 3 - EXECUTION

3.1. **INSTALLATION**

3.1.1. Circuit breakers in panelboards shall be factory installed.

3.1.2. Install individual breakers where indicated.

3.1.3. New Circuit Breakers in Existing Panelboards:

3.1.3.1. Circuit breakers shall be of standard manufacture and match existing devices.
3.1.3.2. Circuit breakers shall be “bolt-on” type.
3.1.3.3. Circuit breakers shall have an AIC rating compatible with the Building’s short circuit analysis report.

3.2. **FIELD QUALITY CONTROL**

3.2.1. Perform tests and inspections.

3.2.2. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

3.2.3. Acceptance Testing Preparation:

3.2.3.1. Test insulation resistance for each enclosed switch and circuit breaker, component, connecting supply, feeder, and control circuit.
3.2.3.2. Test continuity of each circuit.

3.2.4. Tests and Inspections:

3.2.4.1. Perform each visual and mechanical inspection and electrical test stated in Acceptance Testing Specification. Certify compliance with test parameters.
3.2.4.2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
3.2.4.3. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.
3.2.4.4. Enclosed switches and circuit breakers will be considered defective if they do not pass tests and inspections.
3.2.4.5. Prepare test and inspection report, including a certified report that identifies enclosed switches and circuit breakers and that describes scanning results. Include notation of deficiencies detected, remedial action taken and observations after remedial action.

3.3. **ADJUSTING**

3.3.1. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.

3.3.2. Set field-adjustable circuit-breaker trip ranges. Provide list of “as left” settings and submit to Client

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PART 1 - GENERAL

1.1. **DESCRIPTION**

1.1.1. This section specifies the furnishing, installation, and connection of fused and unfused disconnect switches (indicated as switches in this section), circuit breaker distribution panels and separately-enclosed circuit breakers for use in electrical systems rated 600 V and below.

1.2. **RELATED WORK**

1.2.1. Section: 26 05 00 Common Work Results for Electrical.

1.2.2. Section: 26 05 19 Low-Voltage Electrical Power Conductors and Cables.

1.2.3. Section: 26 05 33 Raceway and Boxes for Electrical Systems.

1.3. **SUBMITTALS**

1.3.1. Submit the following.

1.3.1.1. Shop Drawings:

1.3.1.1.1. Submit sufficient information to demonstrate compliance with drawings and specifications.

1.3.1.1.2. Submit the following data for approval:

1.3.1.1.3. Electrical ratings, dimensions, mounting details, materials, required clearances, terminations, weight, fuses, circuit breakers, wiring and connection diagrams, accessories, and device nameplate data.

1.3.1.2. Manuals:

1.3.1.2.1. Submit complete maintenance and operating manuals including technical data sheets, wiring diagrams, and information for ordering fuses, circuit breakers, and replacement parts.

1.3.1.2.2. Include schematic diagrams, with all terminals identified, matching terminal identification in the enclosed switches and circuit breakers.

1.3.1.2.3. Include information for testing, repair, troubleshooting, assembly, and disassembly.

1.3.1.2.4. If changes have been made to the maintenance and operating manuals originally submitted, submit updated maintenance and operating manuals two weeks prior to the final inspection.

1.3.1.2.5. Certifications: Two weeks prior to final inspection, submit the following.

1.3.1.2.6. Certification by the manufacturer that the enclosed switches and circuit breakers conform to the requirements of the drawings and specifications.

1.3.1.2.7. Certification by the Contractor that the enclosed switches and circuit breakers have been properly installed, adjusted, and tested.

1.4. **APPLICABLE PUBLICATIONS**

1.4.1. Publications listed below (including amendments, addenda, revisions, supplements, and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by designation only.

1.4.2. CAN/CSA-22.2

1.4.2.1. CAN/CSA-C22.2 No. 4-04 (R2009), Enclosed Switches.
1.4.2.2. CAN/CSA C22.2 NO.39-M1987 (R2007) Fuseholder Assemblies).

1.4.3. National Electrical Manufacturers Association (NEMA):

1.4.3.1. Low Voltage Cartridge Fuses
1.4.3.2. Enclosed and Miscellaneous Distribution Equipment Switches (600 Volts Maximum)

1.4.4. National Fire Protection Association (NFPA):

1.4.4.1. 70-11 National Electrical Code (NEC)

1.4.5. Underwriters Laboratories, Inc. (UL):

1.4.5.1. 98-07 Enclosed and Dead-Front Switches
1.4.5.2. 248-00 Low Voltage Fuses
1.4.5.3. 489-09 Molded Case Circuit Breakers and Circuit Breaker Enclosures

PART 2 - PRODUCTS

2.1. **PANELBOARD-MOUNTED FUSED DISCONNECTS**

2.1.1. Circuit breakers shall be per CAN/CSA22.2 #4, UL, NEC, as shown on the drawings, and as specified.

2.1.2. For circuit breakers being added to existing panelboards, coordinate the breaker type with existing panelboards. Modify the panel directory accordingly.

2.1.3. Circuit breakers shall be bolt-on type.

2.1.4. Circuit breakers shall have minimum interrupting rating as required to withstand the available fault current, but not less than:

2.1.4.1. 120/208 V Panelboard: 10,000 A symmetrical.
2.1.4.2. 120/240 V Panelboard: 10,000 A symmetrical.
2.1.4.3. 347/575 V Panelboard: 14,000 A symmetrical.

2.1.4.4. Circuit breakers shall have automatic, trip free, non-adjustable, inverse time, and instantaneous magnetic trips for less than 400 A frame. Circuit breakers with 400 A frames and above shall have magnetic trip, adjustable from 5x to 10x.

2.1.5. Circuit breaker features shall be as follows:

2.1.5.1. A rugged, integral housing of molded insulating material.
2.1.5.2. Silver alloy contacts.
2.1.5.3. Arc quenchers and phase barriers for each pole.
2.1.5.4. Quick-make, quick-break, operating mechanisms.
2.1.5.5. A trip element for each pole, thermal magnetic type with long time delay and instantaneous characteristics, a common trip bar for all poles and a single operator.
2.1.5.6. Electrically and mechanically trip free.
2.1.5.7. An operating handle which indicates closed, tripped, and open positions.
2.1.5.8. An overload on one pole of a multi-pole breaker shall automatically cause all the poles of the breaker to open.
2.1.5.9. Ground fault current interrupting breakers, shunt trip breakers, lighting control breakers (including accessories to switch line currents), or other accessory devices or functions shall be provided where shown on the drawings.

2.2. **FUSED DISCONNECT SWITCHES RATED 600 AMPERES AND LESS**

2.2.1. Switches shall be in accordance with CAN/CSA22.2 #4, NEMA, NEC, UL, as specified, and as shown on the drawings.

2.2.2. Shall be NEMA classified General Duty (GD) for 240 V switches, and NEMA classified Heavy Duty (HD) for 575 V switches.

2.2.3. Shall be horsepower (HP) rated.

2.2.4. NEMA 1 (indoor applications), NEMA 3R (outdoor or wet environment))

2.2.5. Shall have the following features:

2.2.5.1. Switch mechanism shall be the quick-make, quick-break type.
2.2.5.2. Copper blades, visible in the open position.
2.2.5.3. An arc chute for each pole.
2.2.5.4. External operating handle shall indicate open and closed positions, and have lock open padlocking provisions.
2.2.5.5. Mechanical interlock shall permit opening of the door only when the switch is in the open position, defeatable to permit inspection.
2.2.5.6. Fuse holders for the sizes and types of fuses specified.

2.2.5.7. Solid neutral for each switch being installed in a circuit which includes a neutral conductor.

2.2.5.8. Ground lugs for each ground conductor.

2.2.6. Enclosures:

2.2.6.1. Shall be the NEMA types shown on the drawings.

2.2.6.2. Where the types of switch enclosures are not shown, they shall be the NEMA types most suitable for the ambient environmental conditions.

2.2.6.3. Shall be finished with manufacturer's standard gray baked enamel paint over pretreated steel.

2.2.7. Standards of Acceptance: Eaton, Cutler Hammer, Siemens, Square D

2.3. **UNFUSED DISCONNECT SWITCHES RATED 600 AMPERES AND LESS**

2.3.1. Shall be the same as fused switches, but without provisions for fuses.

2.3.2. Standards of acceptance: same as fused disconnects

2.4. **CIRCUIT BREAKER TYPE DISTRIBUTION PANELS**

2.4.1. Distribution panels conforming to CSA C22.2 no. 29 standard.

2.4.2. Supplied by the same and only manufacturer.

2.4.3. As specified on the drawings

2.4.4. Arrange bus bars per phase order. All circuits shall be identified by a letter, as shown on drawings.

2.4.5. Panels shall have bus bars, and number of branch circuits and circuit breakers as shown.

2.4.6. Panels to be complete with door, lock and two keys, locks and keys to be interchangeable for all panels of the same type.

2.4.7. Bus bars shall be copper as the supports and circuit breakers material have the same expansion coefficients, with full capacity neutral.

2.4.8. For surface or flush mounting as shown on drawings.

2.4.9. Panel bus bars to be compatible with bolted-on circuit breakers.

2.4.10. Standard finish: ASA 61 grey baked enamel.

2.4.11. Circuit breakers: conforming to article "Molded Case Circuit Breakers" described herein.

2.4.12. The grounding bus bar shall conform to article Grounding and Bonding.

2.4.13. Acceptable manufacturers:

2.4.13.1. Eaton, Siemens, GE.

2.5. **MOTOR RATED TOGGLE SWITCHES**

2.5.1. Not applicable

2.6. **CARTRIDGE FUSES**

2.6.1. Shall be in accordance with CSA C22.2 no. 106 and C22.2 no. 248 standards.

2.6.2. High rupturing capacity (HRC) fuses 200kA RMS symmetrical and current limiting fuses.

2.6.3. Supplied by the same and only manufacturer.

2.6.4. Service Entrance: Class L, fast acting.

2.6.5. Feeders: Class L, fast acting

2.6.6. Motor and Transformer Branch Circuits: Class RK1 time delay.

2.6.7. Other Branch Circuits: Class J (less than 600A) or Class L (over 600A), fast acting.

2.6.8. Control Circuits: Class CC fast acting

2.6.9. Standard of Acceptance: Cooper Busman, Eaton

2.7. **MOLDED CASE CIRCUIT BREAKERS**

2.7.1. Molded case circuit breakers conforming to CSA C22.2 no. 5 standard.

2.7.2. Circuit protection devices contained in plastic insulated enclosures.

2.7.3. Bolted to the panel bus bars.

2.7.4. Quick make quick break mechanism.

2.7.5. Manually operated.

2.7.6. Complete with thermal and magnetic trip unit compensated for an ambient temperature of 40 °C (104 °F).

2.7.7. Multi-pole breakers to have a common trip device and operating lever.

2.7.8. In 120 or 208 Volts circuits use, unless otherwise noted on the distribution diagram or on the panel description sheets, single, two or three pole circuit breakers having the ratings as shown and with a 10 kA minimum RMS, symmetrical rupturing capacity.

2.7.9. Authentication of new breakers (not counterfeited)

2.7.9.1. Except otherwise noted, all breakers installed in panels (new or existing) shall be new and obtained exclusively from a distributor authorized by manufacturer.

2.7.9.2. Submit with breaker shop drawings, a copy of the purchase order to the distributor. Quantities, models and sizes shown on the purchase order shall correspond to those indicated on the shop drawings.

PART 3 - EXECUTION

3.1. **INSTALLATION**

3.1.1. Installation shall be in accordance with the manufacturer's instructions, the CEC, as shown on the drawings, and as specified.

3.1.2. Fused switches shall be furnished complete with fuses. Arrange fuses such that rating information is readable without removing the fuses.

3.1.3. All disconnect switches and fuses supplied by the same manufacturer.

3.1.4. Safety switches in the circuit between a motor and a variable frequency drive shall be fitted with one type C auxiliary contact. Connect this contact to the variable frequency drive with two (2) # 14 AWG conductors inside a 12 mm (½") conduit.

3.2. **MOLDED CASE CIRCUIT BREAKER**

3.2.1. Install circuit breakers and connect as shown.

3.2.2. When a panel is replaced with a new one, the contractor shall verify the compatibility of the existing breakers with the new panel type. New breakers shall be supplied if the existing breakers are not compatible with the new panel and cannot be relocated.

3.3. **FUSES**

3.3.1. Install fuses in fuse holders just before energizing.

3.3.2. Ensure that fuses and holders are perfectly matched.

3.3.3. Ensure that the right fuse is used to protect the corresponding circuit.

3.3.4. Store the spare fuses in an orderly manner

3.4. **IDENTIFICATION**

3.4.1. Identify switches, as to equipment served, with engraved laminated phenolic name plates.

3.5. **ACCEPTANCE CHECKS AND TESTS**

3.5.1. Perform in accordance with the manufacturer's recommendations. In addition, include the following:

3.5.2. Visual Inspection and Tests:

3.5.2.1. Compare equipment nameplate data with specifications and approved shop drawings.

3.5.2.2. Inspect physical, electrical, and mechanical condition.

3.5.2.3. Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method.

3.5.3. Vacuum-clean enclosure interior. Clean enclosure exterior.

3.6. **SPARE PARTS**

3.6.1. Two weeks prior to the final inspection, furnish one complete set of spare fuses for each fused disconnect switch installed on the project. Deliver to the Board representative.