NORTH HASTINGS HIGH SCHOOL
DUST COLLECTOR REPLACEMENT

14 Monck St, Bancroft, Ontario K0L 1C0

HASTINGS AND PRINCE EDWARD DISTRICT SCHOOL BOARD

MECHANICAL & ELECTRICAL SPECIFICATIONS

PROJECT MANUAL VOLUME 2

MOFFET & DUNCAN ARCHITECTS INC.
Prime Consultant

SAB Engineering Inc.
Mechanical & Electrical Consultant

NORTH HASTINGS HIGH SCHOOL

DUST COLLECTOR REPLACEMENT

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. Client'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. Dust Collection System

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:

1.3.1.1.1. N/A

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 duct collection equipment complete with concrete supports, fencing, and accessories.

1.12.1.2. Remove all dust collection ductwork inside woodshop, that is serving existing shop equipment as indicated on the drawings. Remove all associated portable dust collectors, hangers, and other accessories.

1.12.1.3. Disconnect and remove electrical connections to all equipment as indicated on the drawings. Refer to Section 26 05 11 for more detailed electrical scope.

1.12.2. All cutting and patching associated with the removal of the ductwork & conduits 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. **DEMOLITION OF ARCHITECTURAL FINISHES**

3.4.1. 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:

3.4.1.1. 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.

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

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

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

3.4.1.5. Dispose of demolished items and materials promptly.

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

3.4.2. Plaster:

3.4.2.1. 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.

3.4.3. Flooring:

3.4.3.1. 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:

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

3.4.3.1.2. 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.

3.4.3.1.3. 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

3.4.3.1.4. Clean floor slabs of dust and adhesive residue.

3.5. **DEMOLITION OF CONCRETE OR ASPHALT**

3.5.1. 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. DESCRIPTION

1.1.1. Domestic water systems, including piping, equipment and all necessary accessories as designated in this section.

1.2. RELATED WORK

1.2.1. Section: 23 07 00 HVAC Insulation.

1.3. SUBMITTALS

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

1.3.2. Manufacturer's Literature and Data: All items listed in Part 2 - Products.

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. Ontario Building Code – Part 7

1.4.3. American National Standards Institute (ANSI):

1.4.4. A13.1 Scheme for Identification of Piping Systems

1.4.5. B16.3-2011 Malleable Iron Threaded Fittings Classes 150 and 300

1.4.6. B16.9-2007 Factory-Made Wrought Butt Welding Fittings

1.4.7. B16.11-2011 Forged Fittings, Socket-Welding and Threaded

1.4.8. B16.15-2006 Cast Copper Alloy Threaded Fittings Classes 125 and 250

1.4.9. B16.18-2001 Cast Copper Alloy Solder-Joint Pressure Fittings

1.4.10. B16.22-2012 Wrought Copper and Copper Alloy Solder Joint Pressure Fittings

1.4.11. NSF/ANSI 61-2012 Drinking Water System Components - Health Effects

1.4.12. American Society for Testing and Materials (ASTM):

1.4.12.1. A183-03(2009) Carbon Steel Track Bolts and Nuts
1.4.12.2. B32-08 Solder Metal
1.4.12.3. B61-08 Steam or Valve Bronze Castings
1.4.12.4. B75/B75M-11 Seamless Copper Tube

1.4.12.5. B88-09 Seamless Copper Water Tube
1.4.12.6. B584-12a Copper Alloy Sand Castings for General Applications
1.4.12.7. B687-99(2011) Brass, Copper, and Chromium-Plated Pipe Nipples
1.4.12.8. E1120-08 Liquid Chlorine
1.4.12.9. E1229-08 Calcium Hypochlorite

1.4.13. American Water Works Association (AWWA):

1.4.14. C110/A21.10-12 Ductile Iron and Gray Iron

1.4.15. C151/A21.51-09 Ductile-Iron Pipe, Centrifugally Cast

1.4.16. C153/A21.53-11 Ductile-Iron Compact Fittings

1.4.17. C651-05 Disinfecting Water Mains

1.4.18. NSF International (NSF)

1.4.18.1. NSF/ANSI 61 (2012) Drinking Water System Components – Health Effects
1.4.18.2. NSF/ANSI 372 (2011) Drinking Water System Components – Lead Content

1.5. **QUALITY ASSURANCE**

1.5.1. All piping materials shall be compatible for temperature, pressure and service.

1.5.2. All piping materials of a given type shall be manufactured by a single source, and supplied by a single supplier.

1.5.3. All wetted seals shall be made from materials that are immune from chloramine degradation.

1.5.4. All joint couplings, fittings, valves, and specialties shall be the products of a single manufacturer.

1.5.5. All castings used for coupling housings, fittings, valve bodies, etc., shall be date stamped for quality assurance and traceability.

PART 2 - PRODUCTS

2.1. **MATERIALS**

2.1.1. Material or equipment containing a weighted average of greater than 0.25 percent lead shall not be used in any potable water system intended for human consumption, and shall be certified in accordance with NSF/ANSI 61 or NSF 372. Endpoint devices used to dispense water for drinking must meet the requirements of NSF/ANSI 61, Section 9.

2.2. **ABOVE GROUND (INTERIOR) WATER PIPING**

2.2.1. Pipe: Copper tube, ASTM B88, Type K or L, drawn.

2.2.2. Fittings for Copper Tube:

2.2.2.1. Wrought copper or bronze castings conforming to ANSI B16.18 and B16.22. Unions shall be bronze, MSS SP72 & SP 110, Solder or braze joints. Use 95/5 tin and antimony for all soldered joints.

2.2.2.2. Adapters: Provide adapters for joining screwed pipe to copper tubing.

2.2.3. Unions And Flanges:

2.2.3.1. Unions, flanges and gasket materials to have a pressure rating of not less than 150 psig at 180 degrees. Gasket material for flanges and flanged fittings shall be teflon type. Treated paper gaskets are not acceptable.

2.2.3.2. 50 mm (2") and smaller copper unions:

2.2.3.2.1. ANSI B16.18 cast bronze union coupling or ANSI B15.24 Class 150 cast bronze flanges.

2.2.3.3. 65 mm (2½ ") and larger flanges:

2.2.3.3.1. ANSI B15.24 Class 150 cast bronze flanges with full face teflon gaskets.

2.2.4. Solder: For installation of the potable water systems, only lead free solder shall be used, as required by the Ontario Act. Regulation 815/84 of the Ontario Water Resources.

2.3. **EXPOSED WATER PIPING**

2.3.1. Finished Room: Use full iron pipe size chrome plated brass piping for exposed water piping connecting fixtures, casework, cabinets, equipment when not concealed.

2.3.2. Fittings: ANSI B16.15 cast bronze threaded fittings with chrome finish.

2.3.3. Nipples: ASTM B 687, Chromium-plated.

2.3.4. Unions: Mss SP-72, SP-110, Brass or Bronze with chrome finish. Unions 2-1/2 inches (65 mm) and larger shall be flange type with approved gaskets.

2.3.5. Unfinished Rooms, Mechanical Rooms and Kitchens: Chrome plated brass piping is not required.

2.4. **STRAINERS**

2.4.1. Provide on high pressure side of pressure reducing valves, upstream of solenoid valves, on suction side of pumps, 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.

2.4.2. Water: Basket or "Y" type with easily removable cover and brass strainer basket.

2.4.3. Body: Smaller than 3 inches (80 mm), brass or bronze; 3 inches (80 mm) and larger, cast iron or semi-steel.

2.5. **DIELECTRIC FITTINGS**

2.5.1. Provide dielectric couplings or unions between ferrous and non-ferrous pipe.

2.6. **STERILIZATION CHEMICALS**

2.6.1. Hypochlorite: ASTM E1120-08

2.6.2. Liquid Chlorine: ASTM E1229-08

PART 3 - EXECUTION

3.1. **INSTALLATION**

3.1.1. Install branch piping for water from the piping system and connect to all fixtures, valves, cocks, outlets, casework, cabinets and equipment.

3.1.2. Pipe shall be round and straight. Cutting shall be done with proper tools. Pipe, except for plastic and glass, shall be reamed to full size after cutting.

3.1.3. Install union and shut-off valve on pressure piping at connections to equipment.

3.1.4. Lay out pipe lines straight, plumb and in true alignment. Offset as required to avoid interference with other work, to conceal piping, to allow maximum headroom and to avoid interference with windows and doors. Lay out all pipes and establish their levels from bench marks, existing floors or finished grades.

3.1.5. Do not route piping through transformer vaults or above transformers, panelboards, or switchboards, including the required service space for this equipment, unless the piping is serving this equipment

3.1.6. Piping shall be concealed unless indicated otherwise on drawings. Do not conceal piping until it has been inspected, tested, flushed and approved.

3.1.7. Use eccentric reducing fittings to increase or decrease pipe sizes. Bushings are not acceptable. Orient reducers to prevent trapping of water.

3.1.8. Locate groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves. Install hot and cold water lines at least 6 inches apart. Install piping at least 3 inches clear of electrical conduit and avoid running pipe within 3’-6” of electrical equipment, from floor to ceiling.

3.1.9. Grade all lines to facilitate drainage. Provide drain valves at bottom of risers and all low points in system. Design domestic hot water circulating lines with no traps.

3.1.10. All domestic water piping shall be insulated throughout. For cold water, use vapor barrier.

3.1.11. Connect branch lines at bottom of main serving fixtures below and pitch down so that main may be drained through fixture. Connect branch lines to top of main serving only fixtures located on floor above.

3.2. **COPPER PIPE JOINTS**

3.2.1. Remove all slivers and burrs remaining from the cutting operation by reaming and filing both pipe surfaces. Clean fitting and tube with metal brush, emery cloth or sandpaper. Remove residue from the cleaning operation, apply flux and assemble joint to socket stop. Apply flame to fitting until solder melts when placed at joint. Remove flame and feed solder into joint until full penetration of cup and ring of solder appears. Wipe excess solder and flux from joint.

3.3. **THREADED PIPE JOINTS**

3.3.1. Use a thread lubricant or teflon tape when making joints; no hard setting pipe thread cement or caulking will be allowed.

3.4. **PIPE HANGERS, SUPPORTS AND ACCESSORIES**

3.4.1. All piping shall be supported per the requirements of the Ontario Building Code part 7

3.4.2. 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.

3.4.3. Floor, Wall and Ceiling Plates, Supports, Hangers:

3.4.3.1. Solid or split un-plated cast iron.
3.4.3.2. All plates shall be provided with set screws.
3.4.3.3. Pipe Hangers: Height adjustable clevis type.
3.4.3.4. Adjustable Floor Rests and Base Flanges: Steel.
3.4.3.5. Concrete Inserts: "Universal" or continuous slotted type.
3.4.3.6. 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.
3.4.3.7. Riser Clamps: Malleable iron or steel.
3.4.3.8. Rollers: Cast iron.
3.4.3.9. Self-drilling type expansion shields shall be "Phillips" type, with case hardened steel expander plugs.

3.4.3.10. Hangers and supports utilized with insulated pipe and tubing shall have 180 degree 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.

3.4.4. For cold piping, install hangers and supports to maintain an effective continuous thermal and vapor barrier between cold piping and hangers and supports.

3.4.5. Miscellaneous Materials: As specified, required, directed or as noted on the drawings for proper installation of hangers, supports and accessories.

3.4.6. With the installation of each flexible expansion joint, provide piping restraints for the upstream and downstream section of the piping at the flexible expansion joint. Provide calculations supporting the restraint length design and type of selected restraints.

3.4.7. Install chrome plated cast brass escutcheon with set screw at each wall, floor and ceiling penetration in exposed finished locations and within cabinets and millwork.

3.5. **PENETRATIONS**

3.5.1. Install pipe sleeves where piping passes through building construction including all walls, floors and ceilings.

3.5.2. For new wall construction, promptly and accurately locate and securely set sleeves in forms before concrete is poured. For masonry construction, set the sleeves over the piping for Masonry Contractor to build around.

3.5.3. Fire Stopping: Where pipes 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 as specified in Section: 07 84 00 Fire Stopping. Completely fill and seal clearances between raceways and openings with the fire stopping materials.

3.5.4. Waterproofing: At floor penetrations, completely seal clearances around the pipe and make watertight with sealant

3.6. **TESTS**

3.6.1. General: Test system either in its entirety or in sections.

3.6.2. Potable Water System: Test after installation of piping and domestic water heaters, but before piping is concealed, before covering is applied, and before plumbing fixtures are connected. Fill systems with water and maintain hydrostatic pressure of 150 psi (1040 kPa) gage for two hours. No decrease in pressure is allowed. Provide a pressure gage with a shutoff and bleeder valve at the highest point of the piping being tested.

3.6.3. All Other Piping Tests: Test new installed piping under 1-1/2 times actual operating conditions and prove tight.

3.7. **VALVES INSTALLATION**

3.7.1. Install valves with stem in horizontal position whenever possible. All valves shall be easily accessible. Install valve in each water connection to fixture.

3.7.2. Install union and shut off valve on piping at connections to equipment and at all other locations indicated on the drawings.

3.7.3. Provide isolation valves on all main branch feeds to washroom fixture groups. Where possible, locate all valves in accessible ceilings. In hard ceiling areas, group valves to be accessed from one access door.

3.7.4. Backflow prevention device shall be installed in an accessible location, 5 (five) feet above finish floor.

3.7.5. Connect to fixtures and equipment in accordance with manufacturer's instructions.

3.8. **STERILIZATION**

3.8.1. After tests have been successfully completed, thoroughly flush and sterilize the interior domestic water distribution system in accordance with the Ontario Building Code part 7, the requirements of Authorities Having Jurisdiction and AWWA C651.

3.8.2. Use liquid chlorine or hypochlorite for sterilization.

TABLE OF CONTENTS

PART 1 - GENERAL

1.1. DESCRIPTION

1.1.1. The requirements of this Section apply to all sections of Division 23.

1.2. DEFINITIONS

1.2.1. Exposed: Piping, ductwork, and equipment exposed to view in finished rooms.

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

1.3. RELATED WORK

1.3.1. Section: 01 33 23 Shop Drawings, Product Data, and Samples.

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

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

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

1.3.5. 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

1.11.3.2. New Layout Work

1.11.3.2.1. Provide new dust collection equipment as indicated on drawings and specifications. Install new dust collectors on new concrete pads. Provide new fencing around new dust collectors as indicated on the drawings. Provide and install all required accessories, supports, silencers, abort gate, blast safety equipment, fire suppression, and ductwork related to the dust collection equipment.

1.11.3.2.2. Provide new ductwork throughout the woodshop as indicated on the drawings. Provide new duct branches to individual equipment approximately as indicated on the drawings. Contractor shall coordinate duct drops to equipment with school staff prior to installation. Contractor to allow for additional offsets, transitions, and final connector fittings as required to connect all woodworking equipment. Connect new ductwork to new dust collection equipment outdoors. Contractor shall confirm final duct routing on site prior to installation and perform any necessary modifications as required to complete the installation.

1.11.3.2.3. New dust collection ductwork shall be run at high level through OWSJ in the shop area. Support new ductwork from structure above and provide all required hangers. Coordinate installation of new ductwork with other existing & new services in the ceiling such as ductwork, lighting, structural elements, etc.

1.11.3.2.4. Provide new non-return valve for each dust collector and install as indicated on the drawings.

1.11.3.2.5. Run new DCW cold line approximately as indicated and provide new deluge sprinkler system for each dust collector.

1.11.3.2.6. Provide new recirculation ductwork from the dust collector back to the shop and install approximately as indicated on the drawings. Contractor to confirm final duct routing on site. Provide all required dampers, grilles, and other duct accessories.

1.11.3.2.7. Provide new contactors and required wiring for all equipment to be interlocked with each dust collector system. Refer to electrical drawings & specifications 26 05 100 for more information.

1.11.3.2.8. Provide new dust collector control panel for new dust collector and all required power feeds. Connect new control panel to new dust collector and interlock with shop equipment panel. Refer to control schematic on the drawings for details.

1.11.3.2.9. Provide air balancing at the completion of the work.

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 1 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.*

1.17.3. *Should the contractor select a approved alternate manufacturer, the contractor remains responsible for all structural, electrical, and mechanical adjustments necessary to install the new equipment.*

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. **EQUIPMENT AND MATERIALS IDENTIFICATION**

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

2.9. **FIRESTOPPING**

2.9.1. 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.

2.9.2. 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.

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

2.9.3.1. Contain no flammable or toxic solvents.
2.9.3.2. Release no dangerous or flammable out gassing during the drying or curing of products.
2.9.3.3. Water-resistant after drying or curing and unaffected by high humidity, condensation or transient water exposure.

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

2.9.4. 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:

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

2.9.4.2. 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.

2.9.5. 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.

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

2.9.7. 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.

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

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

2.9.8.2. 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.

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

2.10. **GALVANIZED REPAIR COMPOUND**

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

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

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

2.11.2. Supports for Roof Mounted Items:

2.11.2.1. Equipment: Refer to details on mechanical and structural drawings.

2.11.2.2. Pipe Supports: Refer to details on the drawings.

2.11.2.3. Supports for Indoor Mounted Items

2.11.2.3.1. 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.

2.11.2.3.2. 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.

2.11.2.3.3. 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.

2.11.2.3.4. 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.

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

2.11.2.3.6. 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.

2.11.3. Supports for Piping Systems:

2.11.3.1. 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.

2.11.4. Piping Systems (MSS SP 58):

2.11.4.1. Standard clevis hanger: Type 1; provide locknut.
2.11.4.2. Riser clamps: Type 8.
2.11.4.3. Wall brackets: Types 31, 32 or 33.
2.11.4.4. Roller supports: Type 41, 43, 44 and 46.
2.11.4.5. Saddle support: Type 36, 37 or 38.
2.11.4.6. Turnbuckle: Types 13 or 15. Preinsulate.
2.11.4.7. U bolt clamp: Type 24.

2.11.5. Copper Tube:

2.11.5.1. 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.
2.11.5.2. For vertical runs use epoxy painted or plastic coated riser clamps.
2.11.5.3. For supporting tube to strut: Provide epoxy painted pipe straps for copper tube or plastic inserted vibration isolation clamps.

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

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

2.11.8. Piping with Vertical Expansion and Contraction:

2.11.8.1. Movement up to 20 mm (3/4 inch): Type 51 or 52 variable spring unit with integral turn buckle and load indicator.
2.11.8.2. 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.
2.11.8.3. Convertor and Expansion Tank Hangers: May be Type 1 sized for the shell diameter. Insulation where required will cover the hangers.

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

2.11.9.1. Pre-insulated Calcium Silicate Shields:
2.11.9.1.1. Provide 360 degree water resistant high density 965 kPa (140 psi) compressive strength calcium silicate shields encased in galvanized metal.
2.11.9.1.2. Pre-insulated calcium silicate shields to be installed at the point of support during erection.
2.11.9.1.3. Shield thickness shall match the pipe insulation.
2.11.9.1.4. 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.
2.11.9.1.5. 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.

2.11.9.1.6. 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.

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

2.12. **PIPE PENETRATIONS – ROOFS**

2.12.1. Refer to details on the drawings

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

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

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

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

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

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

2.13.3. 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.

2.13.4. 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.

2.13.5. 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.

2.13.6. 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.

2.13.7. Brass Pipe Sleeves: Provide for pipe passing through quarry tile, terrazzo or ceramic tile floors. Connect sleeve with floor plate.

2.13.8. Sleeves are not required for wall hydrants for fire department connections or in drywall construction.

2.13.9. 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.

2.14. **DUCT PENETRATIONS - ROOFS**

2.14.1. 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.

2.14.2. Refer to details on mechanical and structural drawings.

2.15. **DUCT PENETRATIONS – INTERIOR BUILDING ELEMENTS**

2.15.1. Provide sheet metal sleeves min 150 mm (6”) raised above the penetrated floors. Seal space between sleeves and ducts.

2.15.2. For penetrations through fire rated building elements, refer to details on the drawings.

2.15.3. Provide firestopping for openings through fire and smoke barriers, maintaining minimum required rating of floor, ceiling or wall assembly.

2.16. **SPECIAL TOOLS AND LUBRICANTS**

2.16.1. Furnish, and turn over to the Board, tools not readily available commercially, that are required for disassembly or adjustment of equipment and machinery furnished.

2.16.2. Grease Guns with Attachments for Applicable Fittings: One for each type of grease required for each motor or other equipment.

2.16.3. Refrigerant Tools: Provide system charging/Evacuation equipment, gauges, fittings, and tools required for maintenance of furnished equipment.

2.16.4. Tool Containers: Hardwood or metal, permanently identified for intended service and mounted, or located, where directed by the Consultant.

2.16.5. 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.

2.17. **WALL, FLOOR AND CEILING PLATES**

2.17.1. 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.

2.17.2. 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.

2.17.3. 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. At the completion of the project, clean and prepare all floors in the fan rooms for painting. Cover the entire floors for the mechanical room (in the area of work) with two coats of urethane-based paint (colour: battleship gray). Refer to Section 09 91 00.

3.10.3. In addition, the following special conditions apply:

3.10.3.1. 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.

3.10.4. Material And Equipment Not To Be Painted Includes:

3.10.4.1. Motors, controllers, control switches, and safety switches.
3.10.4.2. Control and interlock devices.
3.10.4.3. Regulators.

3.10.4.4. Pressure reducing valves.
3.10.4.5. Control valves and thermostatic elements.
3.10.4.6. Lubrication devices and grease fittings.
3.10.4.7. Copper, brass, aluminum, stainless steel and bronze surfaces.
3.10.4.8. Valve stems and rotating shafts.
3.10.4.9. Pressure gauges and thermometers.
3.10.4.10. Glass.
3.10.4.11. Name plates.

3.10.5. Control and instrument panels shall be cleaned, damaged surfaces repaired, and shall be touched-up with matching paint obtained from panel manufacturer.

3.10.6. 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

3.10.7. Temporary Facilities: Apply paint to surfaces that do not have existing finish coats.

3.10.8. 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 23 33, SHOP DRAWINGS AND PROJECT DOCUMENTATION.

1.2.2. Section 23 05 00, COMMON WORK RESULTS FOR HVAC.

1.2.3. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

1.2.4. Section 26 29 11, LOW-VOLTAGE MOTOR STARTERS.

1.3. SUBMITTALS

1.3.1. Submit in accordance with Section 01 23 33, SHOP DRAWINGS AND PROJECT DOCUMENTATION, and Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

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 23 33, SHOP DRAWINGS AND PROJECT DOCUMENTATION.

1.3. SUBMITTALS

1.3.1. Submit in accordance with Section 01 23 33, SHOP DRAWINGS AND PROJECT DOCUMENTATION.

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 FANS AND AIR HANDLING EQUIPMENT

3.2.1. 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.

3.3. PIPING ISOLATION

3.3.1. 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.

3.3.2. Use restrained spring isolators for the first three piping supports upstream and downstream of each pump.

3.4. **CEILING SUSPENDED EQUIPMENT**

3.4.1. Restrained spring isolators or neoprene isolation hangers, as indicated on the drawings

3.5. **DUCT CONNECTORS**

3.5.1. At all connections between fans and ductwork, where not provided by the manufacturer.

3.5.2. Exception: kitchen grease exhaust ductwork connection to exhaust fan.

3.6. **ELECTRICAL CONNECTIONS**

3.6.1. 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^{o} loop. Coordinate wiring connections with the electrical sub-trade.

3.7. **INSPECTION**

3.7.1. 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.

3.7.2. 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.

Table of Contents

PART 1 - GENERAL

1.1. **RELATED DOCUMENTS**

1.1.1. Drawings and general provisions of the Contract related to this Section.

1.1.1.1. Division 23 Section 23 21 13 - Hydronic Piping
1.1.1.2. Division 23 Section 23 31 14 - Ductwork

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 23

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 SYSTEMS.

1.2.2. Section 23 31 00, HVAC DUCTS AND CASINGS: Duct Leakage.

1.2.3. Section 23 82 16, AIR COILS

1.2.4. Section 23 34 00, HVAC FANS

1.2.5. Section 23 21 23, HYDRONIC PUMPS

1.2.6. Section 23 37 00, AIR OUTLETS AND INLETS

1.2.7. Section 23 21 13, HYDRONIC PIPING

1.3. **QUALITY ASSURANCE**

1.3.1. Qualifications:

1.3.1.1. TAB Agency: The TAB agency shall be a subcontractor of the Mechanical Contractor and shall report to and be paid by the Mechanical 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 23 33, SHOP DRAWINGS AND PROJECT DOCUMENTATION.

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 11, 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 00, HVAC 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.

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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.

1.2.3. Section: 22 11 16 Domestic Water Piping

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. **HVAC PIPING INSULATION**

2.1.1. Application (as applicable to the project)

2.1.1.1. All hot water heating/glycol
2.1.1.2. All domestic water piping
2.1.1.3. All chilled water/glycol
2.1.1.4. All steam piping
2.1.1.5. All condensate piping
2.1.1.6. All piping conveying water and located in spaces where the temperature can drop below freezing. Also refer to heat tracing specifications
2.1.1.7. All other piping conveying fluids warmer than 30^{O}C or colder than 18^{O}C

2.1.2. Mineral Fiber Or Fiber Glass

2.1.2.1. ASTM C547 (Pipe Fitting Insulation and Preformed Pipe Insulation), class 1, k = 0.037 (0.26) at 24 degrees C (75 deg. F), for use at temperatures from -20 deg. C (-4 deg.F) and up to 230 deg.C (450 deg. F)with an all service vapor retarder jacket with polyvinyl chloride premolded fitting covering.

2.1.2.2. Thickness:

2.1.2.2.1. Piping larger than 75mm (3"): 38 mm thickness
2.1.2.2.2. Piping nominal 25mm-75mm (1-3"): 25 mm thickness
2.1.2.2.3. Piping nominal 19mm (3/4") and less: 12 mm thickness
2.1.2.2.4. Outdoor insulation (any size): increase insulation thickness by 12 mm (½")

2.1.2.3. At fittings and flanges (including water meter and body of roof drains), insulate with wrapped fiberglass insulation of same thickness as adjacent pipe, and cover with pre-molded PVC jackets. Seal edge of jacket with self-sealing vapor barrier tape.

2.1.3. Insulation Facings And Jackets

2.1.3.1. Vapor Retarder, higher strength with low water permeance = 0.02 or less perm rating, Beach puncture 50 units for insulation facing on pipe insulation jackets.

2.1.3.2. Facings and jackets

2.1.3.2.1. Concealed indoor areas:

- Shall be all service type (ASJ) in concealed spaces and PVC Vapor Retarder jacketing in all exposed areas, including mechanical rooms and service areas.
- All service Jacket (ASJ) shall be white kraft bonded to 0.025 mm (1 mil) thick aluminum foil, fiberglass reinforced, with pressure sensitive adhesive closure. Comply with ASTM C1136. Beach puncture 50 units, Suitable for painting without sizing. Jackets shall have minimum 40 mm (1-1/2 inch) lap on longitudinal joints and minimum 75mm (3 inch) butt strip on end joints. Butt strip material shall be same as the jacket. Lap and butt strips shall be self-sealing type with factory-applied pressure sensitive adhesive.
- Standard of Acceptance: Zeston, Ceeco, Proto

2.1.3.2.2. Exposed indoor areas:

- Shall be heavy PVC fitting covers (0.75 mm thickness. Overlap PVC covers on pipe insulation jackets as least 1 inch (25 mm) at each end. Secure fitting covers with manufacturer's attachments and accessories. Seal seams with tape and vapor-retarder mastic.

2.1.3.2.3. Indoor Fittings Jackets

- Pipe fitting insulation covering (jackets): Fitting covering shall be premolded to match shape of fitting and shall be polyvinyl chloride (PVC) minimum thickness 0.7 mm (0.03 inches). Provide color matching vapor retarder pressure sensitive tape.
- Adhesive: Compatible with PVC jacket, and recommended by insulation material manufacturer.
- Standard of Acceptance: Zeston, Ceeco, Proto

2.1.3.2.4. Aluminum Jackets – Outdoor Piping and Fittings

- Aluminum Jacket-Piping systems: ASTM B209, 3003 alloy, H-14 temper, 0.6 mm (0.023 inch) minimum thickness with locking longitudinal joints. Jackets for elbows, tees and other fittings shall be factory-fabricated to match shape of fitting and of 0.6 mm (0.024) inch minimum thickness

aluminum. Fittings shall be of same construction as straight run jackets but need not be of the same alloy. Factory-fabricated stainless steel bands shall be installed on all circumferential joints. Bands shall be 13 mm (0.5 inch) wide on 450 mm (18 inch) centers. System shall be weatherproof if utilized for outside service.

- Field applied vapor barrier jackets shall be provided, in addition to the specified facings and jackets, on all exterior piping as well as on interior piping exposed to outdoor air (i.e.; in ventilated attics, piping in ventilated (not air conditioned) spaces, etc.) The vapor barrier jacket shall consist of a multi-layer laminated cladding with a maximum water vapor permeance of 0.001 perms. The minimum puncture resistance shall be 35 cm-kg (30 inch-pounds) for interior locations and 92 cm-kg (80 inch-pounds) for exterior or exposed locations or where the insulation is subject to damage.
- Neither rivets, screws, staples nor any other fastener capable of penetrating the underlying vapor retarder shall be used to secure the aluminum jacketing.
- Standards of Acceptance: Childers-Lock-on and Pabco-Surfeit.

2.1.4. Pipe Covering Protection Saddles

2.1.4.1. Cold pipe support - indoors: Premolded pipe insulation 180 degrees (half-shells) on bottom half of pipe at supports. Material shall be cellular glass or high density Polyisocyanurate insulation of the same thickness as adjacent insulation. Density of Polyisocyanurate insulation shall be a minimum of 48 kg/m3 (3.0 pcf).

2.1.4.2. Warm or hot pipe supports - indoors: Premolded pipe insulation (180 degree half-shells) on bottom half of pipe at supports. Material shall be high density Polyisocyanurate (for temperatures up to 149 degrees C [300 degrees F]), cellular glass or calcium silicate. Insulation at supports shall have same thickness as adjacent insulation. Density of Polyisocyanurate insulation shall be a minimum of 48 kg/m^3 (3.0 pcf).

2.1.4.3. All piping – outdoors: Metallic shield shall be made of galvanized steel painted on both sides with a minimum two coats of aluminum paint. 180 degree for clevises and roller type hangers and 360 degree for clamp type hangers and supports. Shield and insert length and gauge shall be 400 mm (16") long and min. 2.75 mm (12ga) thickness.

2.1.5. Adhesive, Mastic, Cement

2.1.5.1. Insulation manufacturers' published recommendations.

2.1.6. Mechanical Fasteners

2.1.6.1. Wire: 1.3 mm thick (18 gage) soft annealed galvanized or 1.9 mm (14 gage) copper clad steel or nickel copper alloy.

2.1.6.2. Bands: 13 mm (1/2 inch) nominal width, brass, galvanized steel, aluminum or stainless steel.

2.1.7. Flame And Smoke

2.1.7.1. Unless shown otherwise all assembled systems shall meet flame spread 25 and smoke developed 50 rating as developed under ASTM, NFPA and UL standards and specifications. See paragraph 1.3 "Quality Assurance".

2.2. **FITTINGS, FLANGE AND VALVE INSULATION – HOT AND COLD PIPING**

2.2.1. Factory molded, ASTM C547 or field mitered sections, joined with adhesive or wired in place.

2.2.2. For hot piping finish with a smoothing coat of finishing cement.

2.2.3. For cold fittings, 16 degrees C (60 degrees F) or less, vapor seal with a layer of glass fitting tape imbedded between two 2 mm (1/16 inch) coats of vapor barrier mastic.

2.2.4. Fitting tape shall extend over the adjacent pipe insulation and overlap on itself at least 50 mm (2 inches).

2.2.5. Nominal thickness: same as piping of same size.

2.3. **EQUIPMENT INSULATION**

2.3.1. Applications: all heat exchangers, chilled water pumps, chilled water expansion tanks, chiller headers or evaporator vessels

2.3.2. Flexible Elastomeric Cellular Thermal insulation, ASTM C177, C518, k = 0.039 (0.27) at 24 degrees C (75 degrees F), flame spread not over 25, smoke developed not over 50, for temperatures from minus 4 degrees C (40 degrees F) to 93 degrees C (200 degrees F). No jacket required.

2.4. **DUCTWORK INSULATION**

2.4.1. Application

2.4.1.1. 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.

2.4.1.2. All ductwork running through unheated spaces (attics)

2.4.1.3. All exhaust air ductwork 3m upstream of the point of discharge to the outdoors

2.4.1.4. All fresh air supply ductwork

2.4.1.5. All ductwork mounted outdoors

2.4.1.6. All combustion air ductwork

2.4.2. Round Ductwork or Rectangular Ductwork – any side less than 750 mm (30”)

2.4.2.1. 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.

2.4.2.2. Apply insulation from outlet of air handling equipment to air distribution equipment

2.4.2.3. Jacket

2.4.2.3.1. 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.

2.4.2.3.2. Zero permeability vapour barrier for insulation cladding and jacketing applications

2.4.2.3.3. Cold weather acrylic adhesive applies easily at temperatures as cold as -23°C (-10°F)

2.4.2.3.4. Puncture and Tear resistant

2.4.2.3.5. Self-Adhesive material installs easily with no offsite fabrication required

2.4.2.3.6. Cuts and installs easily on-site, no special tools required

2.4.2.3.7. Flexible, strong, reinforced insulation cladding

2.4.2.3.8. Standard Acceptance: 3M™ VentureClad™ Insulation Jacketing

2.4.3. Round Ductwork - Outdoor

2.4.3.1. 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.

2.4.3.2. Jacket

2.4.3.2.1. 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.

2.4.3.2.2. Zero permeability vapour barrier for insulation cladding and jacketing applications

2.4.3.2.3. Cold weather acrylic adhesive applies easily at temperatures as cold as -23°C (-10°F)

2.4.3.2.4. Puncture and Tear resistant
2.4.3.2.5. Self-Adhesive material installs easily with no offsite fabrication required
2.4.3.2.6. Cuts and installs easily on-site, no special tools required
2.4.3.2.7. Flexible, strong, reinforced insulation cladding
2.4.3.2.8. Standard Acceptance: 3M™ VentureClad™ Insulation Jacketing

2.4.4. Rectangular Ductwork – any side larger than 750 mm (30")

2.4.4.1. 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.

2.4.4.2. 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.

2.4.4.3. Jacket
2.4.4.3.1. 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.
2.4.4.3.2. Zero permeability vapour barrier for insulation cladding and jacketing applications
2.4.4.3.3. Cold weather acrylic adhesive applies easily at temperatures as cold as -23°C (-10°F)
2.4.4.3.4. Puncture and Tear resistant
2.4.4.3.5. Self Adhesive material installs easily with no offsite fabrication required
2.4.4.3.6. Cuts and installs easily on-site, no special tools required
2.4.4.3.7. Flexible, strong, reinforced insulation cladding
2.4.4.3.8. Standard Acceptance: 3M™ VentureClad™ Insulation Jacketing

2.4.5. Outdoor Rectangular Ductwork – any size

2.4.5.1. 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.

2.4.5.2. 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.

2.4.5.3. Jacket

2.4.5.3.1. 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.

2.4.5.3.2. Zero permeability vapour barrier for insulation cladding and jacketing applications

2.4.5.3.3. Cold weather acrylic adhesive applies easily at temperatures as cold as -23°C (-10°F)

2.4.5.3.4. Puncture and Tear resistant

2.4.5.3.5. Self Adhesive material installs easily with no offsite fabrication required

2.4.5.3.6. Cuts and installs easily on-site, no special tools required

2.4.5.3.7. Flexible, strong, reinforced insulation cladding

2.4.5.3.8. Standard Acceptance: 3M™ VentureClad™ Insulation Jacketing

2.4.6. Kitchen Exhaust Ductwork listed under NFPA-96

2.4.6.1. Fire Rated Grease Duct Insulation (High Temperature Flexible Blanket); 1½ inch thick refractory grade fibrous fire barrier material with minimum service temperature design of 2,000 degrees F; aluminum foil laminated on both sides; with a minimum 'k' value of 0.25 and a minimum density of 6 lbs/cu ft; containing no asbestos. Listed by a nationally recognized testing laboratory (NRTL) UL to meet ASTM E 2336, ASTM E119, and with flame spread/smoke minimum rating of 25 / 50 when tested as per ASTM E84/UL 723.

2.4.7. Accessories

2.4.7.1. Closure Materials: Butt strips, bands, wires, staples, mastics, adhesives; pressure-sensitive tapes.

2.4.7.2. Support Materials: Hanger straps, hanger rods, saddles, support rings.

2.4.7.3. 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. <u>Molded Mineral Fiber Pipe and Tubing Covering:</u>

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. <u>Flexible Mineral Fiber Blanket - Ductwork:</u>

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**

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.

TABLE OF CONTENTS

PART 1 GENERAL

GENERAL

.1 This section of the specification shall be read in conjunction with and be governed by the requirements of Section 15010.

.2 This Section of the Specification refers to ductwork serving systems with external static pressures/vacuum from +/-4" (1000 Pa) up to +/-30" w.g (7500 Pa).

DESCRIPTION

.1 Ductwork and accessories for HVAC including the following:

- .1 Dust collection - rigid ductwork and accessories
- .2 Dust collection - flexible ductwork
- .3 Dust collection - blast gates

STANDARD OF ACCEPTANCE

.1 Nordfab Duct Systems,
.2 K&B Duct Systems

QUALITY ASSURANCE

.1 Fire Safety Code: Comply with NFPA 90A, 654, 664.

.2 Duct System Construction and Installation: Referenced SMACNA Standards are the minimum acceptable quality.

.3 Duct Sealing, Air Leakage Criteria, and Air Leakage Tests: as applicable for ductwork Class 2 - applications with moderately abrasive particles in light concentrations.

.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 and provide at least the same level of corrosion resistance.

SUBMITTALS

.1 Submit in accordance with Section 15010, Manufacturer's Literature and Data:

- .1 Round and flat oval duct construction details:
  - .1 Manufacturer's details for duct fittings including elbows, transitions and connectors.
  - .2 Sealants and gaskets.
- .2 Access sections.
- .3 Upper hanger attachments.
- .4 Blast gate dampers
- .5 Flexible connections.
- .6 Instrument test fittings.

APPLICABLE PUBLICATIONS

.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.

.2 ACGIH IV Manual, Chapter 10, Woodworking

.3 Air Moving and Conditioning Association (AMCA):

.1 500D 98 Laboratory Method of Testing Dampers for Rating
.2 500L-99Laboratory Method of Testing Louvers for Rating

.4 American Society for Testing and Materials (ASTM):

.1 A653-01 Standard Specification for Steel Sheet, Zinc Coated (Galvanized) or Zinc-Iron Alloy coated (Galvannealed) by the Hot-Dip process
.2 A1011-02 Standard Specification for Steel Sheet and Strip Hot rolled Carbon structural, High-Strength Low- Alloy and High Strength Low-Alloy with Improved Formability
.3 B209 01 Standard Specification for Aluminum and Aluminum Alloy Sheet and Plate
.4 C1071-00 Standard Specification for Fibrous Glass Duct Lining Insulation (Thermal and Sound Absorbing Material)
.5 E84-01 Standard Test Method for Surface Burning Characteristics of Building Materials

.5 National Fire Protection Association (NFPA):

.1 90A-99 Standard for the Installation of Air Conditioning and Ventilating Systems
.2 NFPA 664 (woodshop ductwork construction)

.6 Sheet Metal and Air Conditioning Contractors National Association (SMACNA):

.1 2nd Edition – 1995 HVAC Duct Construction Standards, Metal and Flexible
.2 1st Edition, 1985 HVAC Air Duct Leakage Test Manual
.3 SMACNA 1520 Round Industrial Ductwork Fabrication

PART 2 PRODUCTS

GALVANIZED STEEL - ROUND DUCTWORK

.1 General

.1 All indoor duct-work shall be of a clamp-together, flanged or welded design.

.2 All exterior ductwork shall be joined by flanged or welded, primed and painted; clamps shall not be used outdoors.

.3 All flanged/clamp/welded together ducting shall be of continuous laser welded construction along the longitudinal seam of the rolled form duct with the exception of the 3” which is lock formed. All connections shall have Nitrile seal in clamp for standard installs.

.2 Ducting shall consist of the following:

.1 Galvanized: ASTM A527 with a G90 rating
.2 Temp rating is 500° F with no breakdown of zinc - Zinc melting point is 740° F

.3 Ducting manufacturing techniques:

.1 Diameters 3" - 24" pipe, adjustable nipples, and collars attached to other components will have one or both ends die formed-rolled to provide a uniform edge around the circumference of the rolled end.

.2 The pipe and adjustable nipples shall have the longitudinal seam laser welded to allow for a tighter slip joint and reduce system pressure losses. All laser welded seams will undergo a light test to ensure there are no voids or imperfections in the system.

.3 Pipe lengths using laser welded seams will not exceed a nominal 60" length. The rolled edges provide structural support at 5' intervals or less and can be interpreted as a stiffener where SMACNA specifications are required. An adjustable nipple is used for adjustment during the install process. Pipe is cut to appropriate length and the adjustable nipple secures the pipe for install.

.4 Paint used on welds: Krylon Industrial Tough Coat, Acrylic Enamel # 1760 Aluminum

.5 Pipe and other components larger than 24" shall utilize either an angle flange or flat flange attached loosely and retained in place using a 3/8" vanstone lip. The pipe shall have a compressed-interlocking lap form seam and not exceed 78" in length. The angle or flat flanges provide structural support at 6'-6" intervals or less and are considered as stiffeners where SMACNA specifications are required.

.6 There will be times when certain components will be air direction sensitive. These components will have an arrow sticker attached showing the proper flow direction.

.7 All ducting and its components shall have been tested to 80" WG using the following gauged reference:

.1 3" will use 22ga material thickness
.2 4" through 12" will use 22ga material thickness
.3 13" through 29" will use 20ga material thickness
.4 30" and above will use 18ga material thickness
.5 All ductwork from non-return valve to dust collector shall be welded, minimum 14 gauge.

.8 Joints - Clamping rolled edged duct:

.1 Clamps shall be constructed with an over-center, spring-lever action for quick connecting of two pieces of ducting. A retaining pin shall be inserted in the handle and an eyelet on the clamp as a safety feature to ensure the handle does not prematurely come undone.

.2 When closing the clamp, the internal seal shall be compressed in such a manner as to cover both rolled beads for optimum sealing capacity in a full 360° pattern.

.3 Caulking and other materials governing system temperature ratings if applicable:

.1 Approved caulk is 3M Scotch Seal Metal Sealant 2084 or equivalent for system temperatures of 250°F or lower
.2 Approved caulk is 3M DP460 two-part epoxy or equivalent for system temperatures of 375°F or lower
.3 Approved caulk is RTV 100 Series, Mil-A-46106B Compliance, UL/FDA/NSF or equivalent for system temperatures of 400°F or lower.

.9 Joints - Welded Systems:

.1 Provide penetration welds at all joints and seams. All welds shall conform to the following Standards:

.1 SMACNA - Managers' Guide to Welding;
.2 AWS D9.1.

.10 Joints - Flanged Systems

.1 Vanstone flange connections with associated gasket.

.2 Joints shall be provided with flange, non-extruding gasket, and 8 mm (5/16") diameter bolts at a maximum spacing of 8" (200 mm) intervals. Minimum flange sizes shall be 1" x 1" x 10 ga. (25 mm x 25 mm x 3.2 mm) for sizes up to 14" (350 mm) and 1½" x 1½" x 10ga (40 mm x 40 mm x 3.2 mm) diameter for sizes over 14" (350 mm).

.11 Sealing gaskets

.1 Buna-N, 70 Duro-Meter hardness with a temperature rating of 250°F maximum and is black in color, used with the adjustable nipple Silicon rubber, ZZ-R-765 Class 2A and 2B grade 770 AMS-3304E and 3304F and 3303G, FDA approved and is red in color, used with the adjustable nipple

.2 Molded gaskets shall meet the material classification of ASTM D-2000 M2BG510 A24 B34 EO14 EO34 EF11 EF21 and used in systems where the temperature rating is 225°F or less and are black in color.

.3 This component shall be made using conductive materials for conductivity.

.4 Sponge O-ring shall meet the material classification of either ASTM D-1056-68 – SBE43 or ASTM D1056-85, 91, 98 – 2B3

.12 Clamp seals shall be made of either of the following:

.1 Nitrile to meet or exceed ASTM D 1056 standards with a temperature rating not to

exceed 158°F constant temperature (or intermittent temperature of 194°F).

.2 ePTFE to meet or exceed FDA /pharmaceutical standards for food usage and not be degraded by any common chemicals in the 0-14 PH range. Temperature rating shall not exceed 600°F.

.13 Conductivity:

.1 Metal-to-metal contact shall be obtained at all joint connections. Die-formed rolled edges are uniform in shape which provides the most consistent contact.

.2 The ears of the clamp contact with the rolled edges and provide maximum conductivity. Conductivity shall be adhered to per NFPA 77 paragraph 8.4.1.1; states all parts of the continuous metal piping system should have a resistance level that does not exceed 10 ohms.

.3 Testing is the responsibility of the installing contractor.

FITTINGS:

.1 Elbows

.1 Standard elbows will have a centerline radii of 1½ times the duct diameter

.2 Standard elbows 3" to 7" are pressed formed, and 8" and larger are gored construction with a lock form standing seam every 15 degrees. Gore type elbows are produced as follows:

.1 1^{O} to 30^{O} 3 gores
.2 31^{O} TO 45^{O} 4 gores
.3 46^{O} TO 60^{O} 5 gores

.2 Branch Fittings

.1 Branch fittings are produced to have a concentric design, as they taper to a specific dimension.

.2 Joints are lapped, spot welded, cleaned, and painted with KRYLON Industrial Tough Coat, Acrylic Enamel #1760 Aluminum. Seams are sealed with 3M Scotch-Seal (R) 2084 grey sealant.

.3 Fitting gauges match the thickness of the largest duct connecting into it.

.4 All standard branch fittings are produced on a 30-degree angle.

.5 All transition fittings eaves shall not exceed 15^{O}

MAXIMUM LEAKAGE RATES

.1 The duct system shall be constructed such that the maximum leakage rate per joint shall not exceed the values indicated in the table below:

DUCT DIAM.	3" W.G.	5" W.G.	7.5 W.G	10" W.G.	15" W.G
4"	0.20	0.25	0.30	0.30	0.35
5"	0.20	0.25	0.30	0.30	0.35
6"	0.20	0.25	0.30	0.30	0.35
7"	0.20	0.25	0.30	0.30	0.35
8"	0.20	0.25	0.30	0.30	0.35
9"	0.20	0.25	0.30	0.30	0.35
10"	0.20	0.25	0.30	0.30	0.35
12"	0.30	0.30	0.40	0.40	0.40
14"	0.30	0.30	0.50	0.70	0.80
16"	0.30	0.40	0.60	0.70	1.00
18"	0.40	0.40	0.70	0.80	1.10
20"	0.40	0.60	0.80	0.90	1.20
22"	0.40	0.60	0.80	1.10	1.40

HANGERS AND SUPPORTS

.1 Contractor shall submit a plan drawing indicating the location of supports for all ductwork and equipment indicating designed load points and weights for review and verification.

.2 Hangers must be designed to support the duct including exterior insulation, and consider the duct to be 50% full of particulate.

.3 Upper Hanger Attachments:

.1 Concrete prior to pour: manufactured concrete inserts. Standard of Acceptance: Myatt Fig. 485.

.2 Concrete after concrete pour: expanded concrete anchors shall be made of steel; powder actuated fasteners shall only be used for slabs thicker than 4" (100 mm) and shall not be used in lightweight aggregate concretes; holes for expanding fasteners shall be drilled either by a carbide bit or by the teeth of the fastener itself. The expansion shield shall be “set” by driving

it into the hole and expanding it with a conical plug.

.3 Steel Joist: Manufactured joist clamp or steel plate washer. Standard of Acceptance: Grinnell: Fig. 61 or 86 for joist, Grinnell: Fig. 60 for plate washer.

.4 Steel Beams: Manufactured beam clamps. Standard of Acceptance: Grinnell: Fig. 60.

ACCESS DOORS

.1 Provide cleanout access doors in horizontal runs of duct adjacent to elbows, junctions with vertical ducts, vertical duct runs and at devices requiring periodic maintenance. The maximum distance between access doors shall not exceed 12' (3650 mm).

.2 Ultra-low leakage, flat oval design, premium quality and performance access door.

.3 Camlock operation for positive seal and easy opening.

.4 Leakage Information:

.1 The maximum leakage at 8" w.g. (2 kPa):

.1 203mm x 127mm (8" x 5"): 1.02 l/min (0.036 cfm)
.2 305mm x 152mm (12" x 6"): 1.8 l/min (0.064 cfm)
.3 457mm x 254mm (18" x 10"): 3.78 l/min (0.133 cfm).

.5 Cleanouts and access doors shall be sized to satisfy their intended use. The height of the opening shall exceed 0.5 times the diameter of the duct measured along its circumference, or 24" (600 mm) whichever is less.

.6 Cleanouts and access doors shall be provided on the top or the side of the duct. Access doors shall not be located on the bottom of the duct.

.7 On small diameter ducts less than 12" (300 mm) removable caps may be installed at terminal ends.

.8 All access doors shall be gasketed and securely sealed.

FLEXIBLE TUBING

.1 Constructed of thermoplastic urethane and reinforced with a steel wire helix, offering superior abrasion resistance.

.2 This hose is suitable for severe service applications including vacuum and high abrasion. Material used in clear hose is FDA acceptable.

.3 Specifications:

.1 Temperature Range: -60^{O}F to 275^{O}F
.2 Standard Color: Clear or Black

.3 Standard Length: 5’ increments with 5’ min
.4 Sizes: 2” to 14" in increments of 1" (2" to 6" diam) and increments of 2" (6" to 14" diam).

.4 Accessories: ring connectors, clamps, duct connectors, quick release clamps, as required to fit rigid collection ductwork and equipment connections. Coordinate number and type of connecting accessories with existing equipment.

.5 Standard of Acceptance: Duravent.

DUCTWORK ACCESSORIES

.1 All ductwork accessories shall be supplied by the ductwork manufacturer

.2 Ductwork accessories shall include:

.1 Blast gates
.2 Floor sweeps c/w wire mesh and normally closed hinged cover

.3 Blast gates: die cast aluminum c/w locking screw, bolted together frame construction, undersized collars to allow slip-in nominally sized ductwork. Available sizes: 2" to 30".

.4 Floor sweeps: 20 ga galvanized body, 16 ga galvanized hinged door, laster welded, suitable for clamping connection to ductwork.

FLEXIBLE DUCT CONNECTIONS

.5 Where duct connections are made to dust collection equipment install a noncombustible flexible connection of 822 g (29 ounce) neoprene coated fiberglass fabric approximately 150 mm (6 inches) wide.

.6 For connections exposed to sun and weather provide Hypalon coating in lieu of neoprene. Burning characteristics shall conform to NFPA 90A.

.7 Securely fasten flexible connections to round ducts with stainless steel or zinc coated iron draw bands with worm gear fastener. For rectangular connections, crimp fabric to sheet metal and fasten sheet metal to ducts by screws 50 mm (2 inches) on center. Fabric shall not be stressed other than by air pressure. Allow at least 25 mm (one inch) slack during operation to ensure that no vibration is transmitted.

PART 3 EXECUTION

RIGID DUCT CONSTRUCTION AND INSTALLATION

.1 Follow SMACNA HVAC Duct Construction Standards.

.2 Install the ductwork in strict accordance with the manufacturer’s instructions and manuals.

.3 Typical straight duct sections come in 5 ft. in length. To shorten to accommodate an existing span, an adjustable nipple is used. Use the manufacturer’s instruction to customize and join the segments of straight ductwork different than 5 ft length. Keep cut pipe in the direction as the air flow.

.4 Secure the clamping system with cotter pins against accidental release as per manufacturer's instructions.

.5 Duct support: horizontal ductwork must be capable of supporting the weight of the system, plus the weight of the duct half-filled with material being conveyed.

.6 Bond and ground all ductwork in accordance with NFPA 654/664.

.7 Seal weather-proof the dust collection penetrations of the exterior wall.

BLAST GATES

.1 Provide blast gates only for the specific purpose of balancing the airflow. Do not use blast gates to isolate equipment from the exhaust system with the intent to reduce the overall airflow requirement.

.2 When possible, install blast gates on horizontal runs and orient the gate so the blade is on the top half of the duct and opens by pulling the blade towards the ceiling.

.3 When possible, blast gates must be installed at a location not easily accessible to shop personnel.

.4 After final balancing and acceptance, secure the blast gates blades and mark their position so that they can be returned to the balanced position if inadvertently moved. When the blast gates cannot be placed out of the reach of shop personnel, then lock the blades in position. For example, drill a hole through the body and blade of the gate and then insert a bolt and tack weld it.

CLEAN-OUT ACCESS DOORS

.1 Install clean-out doors in ductwork that conveys particulate material such as wood dust or blasting grit. Mount clean-out doors on top half of horizontal runs near elbows, junctions, and vertical runs.

FLOOR SWEEPS

.1 Extend floor sweeps all the way to the floor level.

.2 Provide a magnet to trap metallic parts

FLEXIBLE NON-METALLIC DUCTWORK

.1 Flexible ducting shall be permitted for final machine connection in a length not exceeding the minimum required for machine operation.

HANGER AND SUPPORTS

.1 Size hangers and supports in accordance with the requirements of NFPA-664

.2 Space hangers and supports in strict accordance with the manufacturer's instructions, to avoid

excessive loading of the duct joints. Wherever possible, use hanger and supports provided by the ductwork manufacturer.

.3 Ensure that ductwork is supported by structural elements only; use wall-mounted supports and beam mounted supports. Avoid using the roof hollow-core cellular concrete strips. Use minimum 1½ x 1½ x 3/16 steel angles as necessary to extend supports to the existing beams.

FLEXIBLE CONNECTORS

.1 Provide a flexible connector between the dust collector unit and the rectangular duct inlet, to isolate the system from equipment vibrations.

DUCT LEAKAGE TESTS AND REPAIR

.1 Ductwork leak test shall be performed for the entire air distribution system designated as static pressure class 750 Pa (3-inch W.G.) and above.

.2 Test procedure, apparatus and report shall conform to SMACNA Leakage Test manual. The maximum leakage rate allowed is 4 percent of the design air flow rate.

.3 All ductwork shall be leak tested first before enclosed in a shaft or covered in other inaccessible areas.

.4 All tests shall be performed in the presence of the TAB agency. The Test and Balance agency shall measure and record duct leakage and report to the Consultant and identify leakage source with excessive leakage.

.5 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 Consultant.

.6 All tests and necessary repairs shall be completed prior to insulation or concealment of ductwork.

.7 Make sure all openings used for testing flow and temperatures by TAB Contractor are sealed properly.

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PART 1 - GENERAL

1.1. **DESCRIPTION**

1.1.1. Ductwork and accessories for HVAC including the following:

1.1.1.1. Supply air, return air, outside air, exhaust, make-up air, and relief systems.
1.1.1.2. Exhaust duct for chemical fume hoods, kitchen hood exhaust (grease) and “wet exhaust” ducts.

1.1.2. Section Includes:

1.1.2.1. Ductwork materials, plenums, construction, fabrication, and support
1.1.2.2. Galvanized steel ductwork (rectangular, round)
1.1.2.3. Aluminum ductwork
1.1.2.4. Leak-proof ductwork
1.1.2.5. Reinforcing and supports.
1.1.2.6. Flexible duct.
1.1.2.7. Special ductwork construction including exhaust plenums;
1.1.2.8. Duct sealants.
1.1.2.9. Ductwork sealing, inspection, and leakage testing.
1.1.2.10. 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
1.3.1.5. Turning vanes
1.3.1.6. Flexible duct
1.3.1.7. Volume control dampers
1.3.1.8. Fire and smoke dampers

1.3.2. Applicable Publications

1.3.2.1. American Society for Testing and Materials (ASTM):
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
1.3.2.1.3. A1011-09a Standard Specification for Steel, Sheet and Strip, Hot rolled, Carbon, structural, High-Strength Low-Alloy, High Strength Low-Alloy with Improved Formability, and Ultra-High Strength
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. <u>Rectangular Duct Construction</u>

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. **FLEXIBLE AIR DUCT**

2.5.1. 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.

2.5.2. 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.

2.5.3. 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).

2.5.4. Application Criteria:

2.5.4.1. Temperature range: -18 to 93 degrees C (0 to 200 degrees F) internal.
2.5.4.2. Maximum working velocity: 1200 m/min (4000 feet per minute).
2.5.4.3. Minimum working pressure, inches of water gage: 2500 Pa (10 inches) positive, 500 Pa (2 inches) negative.

2.5.5. 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.

2.6. **DUCT ACCESS DOORS**

2.6.1. Provide access doors, sized and located for maintenance work, upstream, in the following locations:

2.6.1.1. Each in-duct coil (hydronic or DX)
2.6.1.2. Each duct mounted coil and humidifier.
2.6.1.3. Each fire damper (for link service), smoke damper and automatic control damper.
2.6.1.4. Each duct mounted smoke detector.

2.6.2. 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.

2.6.3. For rectangular ducts: Refer to SMACNA HVAC Duct Construction Standards (Figure 2 12).

2.6.4. For round and flat oval duct: Refer to SMACNA HVAC duct Construction Standards (Figure 2-11).

2.6.5. 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.

2.6.6. 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.

2.6.7. 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.

2.6.8. 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.

2.7. **VOLUME CONTROL DAMPERS (MANUAL ADJUSTMENT)**

2.7.1. 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.

2.8. **INSTRUMENT TEST FITTINGS**

2.8.1. 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.

2.8.2. 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.

2.9. **DUCTWORK HANGERS AND SUPPORTS**

2.9.1. 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.

2.9.2. Hanging duct, equipment, or accessories with cables or wires is prohibited.

2.9.3. Provide vibration isolation as specified in Related Section.

2.9.4. 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

2.9.5. Upper hanger attachments:

2.9.5.1. For concrete: manufactured concrete inserts.
2.9.5.1.1. Standard of Acceptance: Myatt fig 485.
2.9.5.2. For concrete after concrete pour:
2.9.5.2.1. Expanded concrete anchors shall be made of steel.
2.9.5.3. 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.
2.9.5.4. 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.
2.9.5.5. For steel joist: manufactured joist clamp or steel plate washer.
2.9.5.5.1. Standard of Acceptance: Grinnell fig 61 or 86 for joist clamps.
2.9.5.6. For steel beams: manufactured beam clamps:
2.9.5.6.1. Standard of Acceptance: Grinnell fig. 60

2.9.6. 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.

2.9.7. 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

2.9.8. For round ductwork the duct shall be supported as follows:

2.9.8.1.1. For duct dimensions 900 mm (36'') single strap hangers are acceptable.
2.9.8.1.2. For duct dimensions over 900 mm (36") use trapeze hangers with rods provided on both sides of the duct.
2.9.8.2. Minimum hanger sizes shall be in accordance with Table 4-2 of SMACNA.

2.9.8.3. Loading on trapeze bars shall be in accordance with Table 4-3 of SMACNA

2.9.9. Install supports on both ends of duct turns, branch fittings and transitions.

2.9.10. Do not hang ductwork from piping, ducts, other trades hangers, existing hangers, or equipment.

2.9.11. 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.

2.9.12. Provide supplemental steel required to support ductwork in shafts, mechanical rooms or on the floor where structural steel is not properly positioned.

2.9.13. 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.

2.9.14. Do not modify existing structural steel without approval and a structural engineer's review.

2.9.15. Provide clamping systems that are compatible with the structural steel system of the building.

2.9.16. Use angle iron "V" construction supports or similarly rigid construction for vertical ducting that requires lateral support.

2.9.17. 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)

2.9.18. 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 safing 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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PART 1 GENERAL

1.1 GENERAL

.1 Refer to section 23 05 11 for general conditions and requirements

1.2 SHOP DRAWINGS AND PRODUCT DATA

.1 Submit shop drawings and product data. Indicate the following: fan type, fan curve, motor drive, filters c/w efficiency, wiring diagrams, control diagrams, access doors, and all performance data.

.2 Sound power data for all fans to be provided. Sound power data shall include sound power data for supply fan discharge and sound power levels radiated from the unit.

.3 Indicate all physical characteristics of the unit: footprint, height, clearances, connections, weight, method of securing to concrete support slab.

.4 Submit shop drawings and product data for accessories including but not limited to:

.1 Dust collector control panel c/w wiring diagram
.2 Spark detection/deluge system control panel c/w wiring diagram
.3 Spark detection system c/w wiring diagram and all components
.4 Heat detectors in filter bag area c/w wiring diagram and deluge sprinkler components
.5 Non-return Air Valve (Damper)
.6 Abort Gate c/w wiring diagram and connection to spark detection system
.7 Silencer

1.3 START-UP

.1 Start-up and adjusting services shall be provided by qualified manufacturer’s technicians.

1.4 APPLICABLE PUBLICATIONS

.1 NFPA-664
.2 NFPA-654

1.5 MAINTENANCE DATA AND MANUALS

.1 Provide maintenance data for incorporation into maintenance manual.

1.6 CAPACITY AND PERFORMANCE

.1 As indicated in the equipment schedules

1.7 STANDARD OF ACCEPTANCE

.1 N R Murphy (Basis of Design) – **Pre-Purchased by HPEDSB**

.2 The basis of design for footprint, performance, and weight is N.R. Murphy. Should the contractor select a different manufacturer, the contractor remains responsible for all structural, electrical, and mechanical adjustments necessary to install the new equipment.

PART 2 PRODUCTS

2.1 DUST COLLECTOR

.1 Outdoor mounted dust collector unit, recirculating type, self-cleaning type.

.2 Construction shall be of minimum 11 & 12 gage steel. Major sections shall be welded construction. Bolted construction shall not be used, favoring welded design to reduce possibility of leakage. The collector shall be phosphatized, painted with zinc chromate primer, and OSHA enamel top coat.

.3 Cartridges shall be installed vertically, and removed by sliding on tracks accessible by doors. Doors shall be reinforced by welded channels, and utilize a floating hinge with equi-bearing clamps to provide uniform pressure. Doors shall have neoprene gaskets. Cartridges shall be self-positioning and an entire row shall be locked and sealed in place by means of tracks which are cam locking bars with handles at the door end to easily lock/unlock the cartridges into place.

2.2 EXHAUST FAN

.1 Exhaust fan shall be mounted on the top of the unit. The motor shall be mounted on the side on a pedestal c/w sheaves, belts, adjustable slide base, OSHA style shaft and belt guards and scroll access door.

.2 The exhaust fan shall be type C spark resistant construction

.3 The exhaust fan shall include a transition rectangular to round, to fit the return duct size. The transition shall include a drilled matching flange.

2.3 ELECTRICAL CONTROL PANEL

.1 Fully pre-wired EEMAC12, CSA approved control panel c/w:

- .1 Dust collector exhaust fan starter
- .2 Dust collector filter shaker starter
- .3 Solid state automatic shaker controller c/w timer
- .4 120V controls transformer
- .5 Two pilot lights
- .6 Explosion vent burst sensor c/w IS barrier
- .7 Auxiliary contacts for interface with equipment contactors, fire protection controller and devices.
- .8 Fused door disconnects

.2 Supplied by the dust collector manufacturer

2.4 FILTER UNIT

.1 Pull thru design constructed from 14 ga. wiped galvanized material continuous welded to make air tight. Unit to be angle iron reinforced.

.2 Electric shaker c/w ½ HP motor and weather cover

.3 120 only 5'' dia. x 64.5'' long filter tubes suspended from shaker rack and fitted air-tight on cell plate. Filters to have a 1''x10'' long strap on top to provide tension adjustment.

.4 Filters from polyester spun (terylene) 8 oz. per sq. yard with a permeability of 20 to 30 cfm

.5 Air to cloth ratio: 7.4 to 1

.6 Deflagration venting section c/w NFPA-68 rupture vent(s), burst sensor, & flameless venting device.

.7 Sloped hopper/inlet section c/w material deflector and flanged inlet c/w matching flanges

.8 NFPA-68 no return valve (inlet isolation valve) c/w blade latch, access/cleanout port, dust level sensor, intrinsic control panel, & shut down micro-switch to NFPA-69

.9 Four solid high pressure drum connectors, clamps, and drum lids c/w drum lift racks (1 rack per 2 drums)

.10 Four 45 gal. drums c/w lifting handles, casters, & toggle clamps

.11 Solid welded support legs with cross bracing & mounting pads. Support legs shall include all hardware required to secure the dust collector unit to the concrete support base.

.12 Heat sensor mounted in roof (to be interlocked with spark detection system)

.13 Deluge fire suppression system c/w deluge head, solenoid valve, & strainer (to be interlocked with spark detection system)

.14 Standard of Acceptance: N.R. Murphy Model MKA Series

2.5 ACCESSORIES

.1 Silencer

.1 Full flow in-line silencer c/w silencer media, perforated metal wall, size to match diameter of ductwork c/w matching drilled flanges at both ends, length 57".
.2 Supplied loose, for field installation. Provide all required supports to suit.
.3 Standard of acceptance: N.R.Murphy

.2 Vigiflap Non-Return Air Valve

.1 Heavy duty ATEX certified welded steel construction
.2 Flanged inlet and outlet, c/w transition to match duct size.
.3 Includes access door and grounding lug
.4 Includes clean-out port
.5 Compliant with NFPA-69 - includes and micro-switch for system tripping, dust level sensor and intrinsically safe control panel.
.6 Provide support to suit.
.7 Standard of Acceptance: BOSS Products EcoMAXX, Flamex

.3 Deluge Valve Station

.1 Suitable for dry system, electronic activation by the heat sensors in the bag filter section. Open head deluge sprinklers sized to provide 0.2 gpm/sq.ft (10.2 l/min/m^2) of bag filter area.
.2 Complete with 120V control panel
.3 Standard of Acceptance: HansenTEK 902-1 Spray Assembly

.4 Fan Maintenance Access Platform

.1 Railings
.2 Self-closing gate
.3 Ladder from grade with 6ft lockable cover.

.5 Pre-wired Dust Collector Control Panel

.1 CSA Approved
.2 Exhauster soft starter
.3 Shaker starter
.4 Solid state automatic shaker controller
.5 Explosion vent burst sensor interlock, shutdown relay, and fault light
.6 120V control transformer
.7 Start/stop key switch
.8 Emergency-shut off push button
.9 Pilot lights
.10 NRV shutdown interlock contacts
.11 NO/NC auxiliary contacts for interlocking
.12 Fused door disconnect

3 EXECUTION

3.1 INSTALLATION

.1 Install units in strict accordance with manufacturer's instructions and as indicated. Maintain service clearances as indicated on the equipment manuals. Secure new equipment to the concrete pad in accordance with the manufacturer's instructions, using manufacturer-supplied parts and accessories.

.2 Coordinate the location of new control panels and other electrical devices with the existing

services located on the wall.

.3 Connect equipment to power supply and provide all interlocking wiring and devices with woodworking equipment, fire protection control panel, fire alarm panel, emergency shut-off push button and other equipment as noted on the sequence of operations.

.4 Provide all necessary equipment disconnects, including outdoor weather-proof units as shown on the drawings. Make all electrical connections to provide a fully operational system.

.5 Provide all piping connections to the spray nozzles booster system and filter bag deluge system.

.6 Provide all controls wiring to meet the NFPA 654/664 requirements, manufacturer's instruction and as shown on the drawings. Include all necessary devices (relays, buttons, disconnects, transformers, contactors, wiring, etc) to make a complete and functional installation

.7 Provide full grounding to all components of the dust collector.

.8 Build the equipment concrete pad in accordance with the manufacturer' instructions

.9 Start-up and adjustments: by manufacturer's representative. Cost to be covered by the mechanical contractor.

.10 Provide a new set of filters and dust collection bins at job completion. Filters and bins to be supplied by unit manufacturer.

.11 Supply and install a new chain-link fence around the unit, complete with lock-able gates. The fence shall be sized such as to allow adequate clearance for maintenance around the dust collector. The gates shall be sized and located such as to facilitate the replacement of dust bins and maintenance/replacement of dust collector parts.

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PART 1 - GENERAL

1.1. DESCRIPTION

1.1.1. This section applies to all sections of Division 26.

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.

1.20. **INTENT**

1.20.1. 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. Electrical contractor shall consider all drawings when preparing their bid price and ensure all work is included for.

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

1.20.2.1. Remove existing electrical connections to existing equipment including dust collector, and local receptacles as noted.

1.20.2.2. Provide new adequately sized fused disconnect to serve new dust collection equipment. Connect to existing Main Electrical Room. Provide new dust collector control panel as per the dust collector manufacturer for each new collector. Provide all new wiring between new fused disconnect, dust collector control panel, and new dust collector. All new wiring to be in EMT conduit indoors and Rigid Aluminum Conduit outdoors. Provide additional weatherproof disconnects, convenience outlets, and fuses as shown on the drawings, and as required to have an operational system.

1.20.2.3. Final routing of new feeders from Main Electrical Room to new dust collector to be verified on site by the Contractor. Include for removal & reinstallation of corridor ceiling as required to complete the new conduit installation. This includes removal of T-bar sections, lighting, and other devices installed in the ceiling space.

Any removed fire alarm devices shall be re-verified upon reinstallation. Provide adequate support for new conduits along entire run.

1.20.2.4. Provide and install new emergency push buttons for new dust collector control. Provide all required wiring, contactors, and relays, between new devices and dust collector panel.

1.20.2.5. Provide new contactors for interlocking existing electrical panels with respective dust collector. Provide all required wiring in conduit between panels, contactors, and dust collector control panels.

1.20.2.6. Provide all required abort gate, deluge fire suppression, non-return valve, and shutdown wiring for new dust collectors as shown on the drawings and as required by the equipment manufacturer.

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

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 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

1.2.2. Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS.

1.2.3. Section 26 05 33, CONDUITS 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-09 Equipment 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.

1.2.4. Section: 26 24 19 Motor-Control Centers.

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

Table of Contents

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 11 GENERAL REQUIREMENTS – ELECTRICAL INSTALLATIONS

1.3. QUALITY ASSURANCE

1.3.1. Refer to Paragraph, QUALIFICATIONS, in Section 26 05 11, GENERAL REQUIREMENTS – ELECTRICAL INSTALLATIONS.

1.4. SUBMITTALS

1.4.1. Submit in accordance with Section 26 05 11, GENERAL REQUIREMENTS – ELECTRICAL INSTALLATIONS.

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 11, ELECTRICAL GENERAL REQUIREMENTS:

1.2.2. Section 26 05 19, CONDUCTORS AND CABLES:

1.2.3. Section 26 05 33, CONDUITS 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.

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PART 1 - GENERAL

1.1. DESCRIPTION

1.1.1. This section specifies the furnishing, installation, connection, and testing of motor controllers, including all low-voltage motor controllers and manual motor controllers, indicated as motor controllers in this section.

1.1.2. Motor controllers, whether furnished with the equipment specified in other sections or otherwise (with the exception of fire pump controllers), shall meet this specification and all related specifications.

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

1.4. SUBMITTALS

1.4.1. Submit documentation in accordance with Section: 26 05 00 Common Work Results for Electrical.

1.4.2. Shop Drawings:

1.4.2.1. Submit sufficient information to demonstrate compliance with drawings and specifications.

1.4.2.2. Include electrical ratings, dimensions, weights, mounting details, materials, over current protection devices, overload relays, sizes of enclosures, wiring diagrams, starting characteristics, interlocking, and accessories.

1.4.3. Manuals:

1.4.3.1. Submit, simultaneously with the shop drawings, companion copies of complete maintenance and operating manuals, including technical data sheets, wiring diagrams, and information for ordering replacement parts.

1.4.3.2. Wiring diagrams shall have their terminals identified to facilitate installation, maintenance, and operation.

1.4.3.3. Wiring diagrams shall indicate internal wiring for each item of equipment and interconnections between the items of equipment.

1.4.3.4. Elementary schematic diagrams shall be provided for clarity of operation.

1.4.3.5. Include the catalog numbers for the correct sizes of overload relays for the motor controllers.

1.4.3.6. 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.

1.4.3.7. Certifications: Two weeks prior to final inspection, submit the following.

1.4.3.8. Certification by the manufacturer that the motor controllers conform to the requirements of the drawings and specifications.

1.4.3.9. Certification by the Contractor that the motor controllers 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 referenced in the text by basic designation only.

1.5.1.1. CSA22.1 – Canadian Electrical Code part 1

1.5.1.2. UL® 198C - High-Interrupting Capacity Fuses; Current Limiting Type.

1.5.1.3. UL 198E - Class R Fuses.

1.5.1.4. NECA, "Standard of Installation" - published by National Electrical Contractors Association.

1.5.1.5. NEMA AB 1 - Molded Case Circuit Breakers.

1.5.1.6. NEMA ICS 2 - Industrial Control Devices, Controllers, and Assemblies.

1.5.1.7. NEMA ICS 6 - Enclosures for Industrial Controls and Systems.

1.5.1.8. NEMA KS 1 - Enclosed Switches.

1.5.1.9. Institute of Electrical and Electronic Engineers (IEEE):

1.5.1.9.1. 519-92 Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems

1.5.1.9.2. C37.90.1-02Standard Surge Withstand Capability (SWC) Tests for Relays and Relay Systems Associated with Electric Power Apparatus

1.5.1.10. National Electrical Manufacturers Association (NEMA):

1.5.1.10.1. ICS 1-08 Industrial Control and Systems: General Requirements

1.5.1.10.2. ICS 1.1-09 Safety Guidelines for the Application, Installation and Maintenance of Solid State Control

1.5.1.10.3. ICS 2-05 Industrial Control and Systems Controllers, Contactors, and Overload Relays Rated 600 Volts

1.5.1.10.4. ICS 4-05 Industrial Control and Systems: Terminal Blocks

1.5.1.10.5. ICS 6-06 Industrial Control and Systems: Enclosures

1.5.1.10.6. ICS 7-06 Industrial Control and Systems: Adjustable-Speed Drives

1.5.1.10.7. ICS 7.1-06 Safety Standards for Construction and Guide for Selection, Installation, and Operation of Adjustable-Speed Drive Systems

1.5.1.10.8. MG 1 Part 31 Inverter Fed Polyphase Motor Standards

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):

1.5.1.12.1. 508A-07 Industrial Control Panels

1.5.1.12.2. 508C-07 Power Conversion Equipment

1.5.1.12.3. UL 1449-06 Surge Protective Devices

1.6. **STANDARDS OF ACCEPTANCE**

1.6.1. Cutler Hammer

1.6.2. Square D/Schneider Electric

1.6.3. Siemens

1.6.4. Eaton Canada

PART 2 - PRODUCTS

2.1. **MOTOR STARTERS**

2.1.1. Starters shall be CSA and ULC approved. Motor controllers shall comply with IEEE, NEMA, NFPA, UL, and as shown on the drawings.

2.1.2. Starters shall be full voltage, non-reversing magnetic starters. Full protection is to be provided in the starters by means of one thermal overload relay per phase per starter with manual reset button to suit the service factor and acceleration time of the motor served.

2.1.3. Unless specified otherwise, motor starters shall be combination type, with magnetic controller and with circuit breaker, fused disconnect switch, motor circuit protector or disconnecting means, with external operating handle with lock-open padlocking positions and ON-OFF position indicator, as applicable to the project and as indicated on the drawings.

2.1.4. Starters shall be equipped with auxiliary contacts to satisfy interlocking and automatic control requirements, “Hand-Off-Automatic” switches, pilot lights (green-On; red-Off), thermal overloads, necessary fuses and control transformer (if required) for operation of all controls on 120V single phase.

2.1.5. Where required by applicable codes, starters shall be equipped with “quick-make” and “quick-break” fused disconnects.

2.1.6. Motor controllers shall be separately enclosed, unless part of another assembly. For installation in motor control centers, provide plug-in, draw-out type motor controllers up through NEMA size 4. NEMA size 5 and above require bolted connections.

2.1.7. Motor Circuit Protectors:

2.1.7.1. Magnetic trip only.
2.1.7.2. Bolt-on type with a minimum interrupting rating as indicated on the drawings.
2.1.7.3. Equipped with automatic, adjustable magnetic trip. Magnetic trip shall be adjustable up to 1300% of the motor full load amperes.

2.1.8. Enclosures:

2.1.8.1. Enclosures shall be NEMA-type rated 1, 3R, or 12 as indicated on the drawings or as required per the installed environment.
2.1.8.2. Enclosure doors shall be interlocked to prevent opening unless the disconnecting means is open. A "defeater" mechanism shall allow for inspection by qualified personnel with the disconnect means closed. Provide padlocking provisions.
2.1.8.3. All metal surfaces shall be thoroughly cleaned, phosphatized, and factory primed prior to applying light gray baked enamel finish.

2.1.9. Motor control circuits:

2.1.9.1. Shall operate at not more than 120 Volts.
2.1.9.2. Shall be grounded, except where the equipment manufacturer recommends that the control circuits be isolated.
2.1.9.3. For each motor operating over 120 Volts, incorporate a separate, heavy duty, control transformer within each motor controller enclosure.
2.1.9.4. Incorporate primary and secondary overcurrent protection for the control power transformers.

2.1.10. Overload relays:

2.1.10.1. Thermal type. Devices shall be NEMA type.
2.1.10.2. One for each pole.
2.1.10.3. External overload relay reset pushbutton on the door of each motor controller enclosure.
2.1.10.4. Overload relays shall be matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.
2.1.10.5. Thermal overload relays shall be tamperproof, not affected by vibration, manual reset, sensitive to single-phasing.

2.1.11. Incorporate into each control circuit a 120 Volt, electronic time-delay relay (ON delay), minimum adjustable range from 0.3 to 10 minutes, with transient protection. Time-delay relay is not required where H O A switch is not required.

2.1.12. Unless noted otherwise, equip each motor controller with not less than two normally open (N.O.) and two normally closed (N.C.) auxiliary contacts.

2.1.13. Provide green (RUN) and red (STOP) pilot lights.

2.1.14. Motor controllers incorporated within equipment assemblies shall also be designed for the specific requirements of the assemblies.

2.1.15. Additional requirements for specific motor controllers, as indicated in other specification sections, shall also apply.

2.2. **COMBINATION MAGNETIC STARTER-FUSED/NON-FUSED DISCONNECT**

2.2.1. Description: Combine magnetic motor controllers as noted above with non-fusible or fusible switch disconnect in common enclosure (as specified and shown on the drawings). Switch shall have a color coded externally operated handle. Operating handle shall give positive visual indication of ON/OFF with red and black color-coding.

2.2.2. Non-fusible Switch Assemblies: NEMA KS 1, enclosed knife switch with externally operable handle and visible blades. Operating handle shall give positive visual indication of ON/OFF with a color-coded operating handle.

2.2.3. Fusible Switch Assemblies: NEMA KS 1, enclosed knife switch with externally operable handle. Fuse clips: Designed to accommodate Class [R] [J] fuses and visible blades. Operating handle shall give positive visual indication of ON/OFF with a color-coded operating handle.

2.2.4. Switch shall have fuse clips to accept time delay, one-time fuse, voltage as noted on the drawings, UL 198E, Class RK 1. Interrupting Rating: 200,000 rms amperes.

2.2.5. Magnetic Motor Controllers: NEMA ICS 2, ac general-purpose Class A magnetic controller for induction motors rated in horsepower.

2.2.6. Coil: Be of encapsulated type.

2.2.7. Poles: as indicated on the drawings and wiring schedules

2.2.8. Contacts: Totally enclosed, double-break, silver-cadmium-oxide power contacts. Contact inspection and replacement shall be possible without disturbing line or load wiring.

2.2.9. Wiring: Straight-through wiring with all terminals clearly marked.

2.2.10. Overload Relay: NEMA ICS

2.2.11. Melting Alloy: With one-piece thermal unit construction. Thermal units shall be interchangeable. Overload relay control circuit contact shall be replaceable. Thermal units shall be required for starter to operate.

2.2.12. Solid State: Trip current rating will be established by selection of overload relay and shall be adjustable (3 to 1 current range). The overload shall be self-powered, provide phase loss and phase unbalance protection, have a permanent tamper guard and be ambient insensitive. It will also be available in Trip Class 10 or 20 and have a mechanical test function.

2.2.13. Outputs: Unit will be designed for addition of either a normally open or normally closed

2.2.14. auxiliary contact and be field convertible.

2.2.15. Reset: Unit shall offer both manual reset and remote reset using an external module.

2.2.16. Enclosure: ANSI/NEMA ICS 6, Type 1 or 3R as required to meet conditions of installation.

2.2.17. Auxiliary Contacts: NEMA ICS 2 normally open and two normally closed contacts in addition to seal-in contact.

2.2.18. Cover Mounted Pilot Devices: NEMA ICS 2, standard duty type.

2.2.19. Pilot Device Contacts: NEMA ICS 2, Form Z, rated A150

2.2.20. Push Buttons: Unguarded Shrouded type.

2.2.21. Indicating Lights: incandescent type.

2.2.22. Selector Switches: Rotary type.

2.2.23. Relays: NEMA ICS 2.

PART 3 - EXECUTION

3.1. **INSTALLATION**

3.1.1. Install motor controllers in accordance with the CEC, NEC, as shown on the drawings, and as recommended by the manufacturer.

3.1.2. Install manual motor controllers in flush enclosures in finished areas. Select location to maintain handle at 1.5 m (5 ft) above the floor level.

3.1.3. Set field-adjustable switches, auxiliary relays, time-delay relays, timers, and electronic overload relay pickup and trip ranges.

3.1.4. Adjust trip settings of circuit breakers and motor circuit protectors with adjustable instantaneous trip elements (where applicable).

3.2. **ACCEPTANCE CHECKS AND TESTS**

3.2.1. Perform manufacturer's required field tests in accordance with the manufacturer's recommendations. In addition, include the following:

3.2.1.1. Visual Inspection and Tests:
3.2.1.2. Compare equipment nameplate data with specifications and approved shop drawings.
3.2.1.3. Inspect physical, electrical, and mechanical condition.
3.2.1.4. Verify appropriate anchorage, required area clearances, and correct alignment.
3.2.1.5. Verify that circuit breaker, motor circuit protector, and fuse sizes and types correspond to approved shop drawings.
3.2.1.6. Verify overload relay ratings are correct.
3.2.1.7. Vacuum-clean enclosure interior. Clean enclosure exterior.
3.2.1.8. Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data.
3.2.1.9. Test all control and safety features of the motor controllers.
3.2.1.10. For low-voltage variable speed motor controllers, final programming and connections shall be by a factory-trained technician. Set all programmable functions of the variable speed motor controllers to meet the requirements and conditions of use.

3.3. **FOLLOW-UP VERIFICATION**

3.3.1. Upon completion of acceptance checks, settings, and tests, the Contractor shall show by demonstration in service that the motor controllers are in good operating condition and properly performing the intended functions.

3.4. **SPARE PARTS**

3.4.1. Two weeks prior to the final inspection, provide one complete set of spare fuses for each motor controller.

3.5. **INSTRUCTION**

3.5.1. Furnish the services of a factory trained technician for two 4 hour training periods for instructing personnel in the maintenance and operation of the motor controllers, on the dates requested by the Board.