

LAMBTON AREA WATER SUPPLY SYSTEM

ADMIN OFFICE
1215 FORT STREET
SARNIA, ONTARIO

HVAC AND BAS UPGRADE

TECHNICAL SPECIFICATIONS

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**Lambton Area Water Supply System - Admin Office
HVAC and BAS Upgrade**

Table of Contents

Section 01 00 00 Project Procedures	1
Section 05 10 00 Structural Metal.....	33
Section 07 52 00 Roofing.....	36
Section 23 00 00 Mechanical Equipment.....	38
Section 23 05 15 Common Piping	54
Section 23 05 93 Balancing	71
Section 23 30 00 Ductwork.....	76
Section 25 30 00 Building Control Devices	91
Section 25 50 00 Building Control Systems	108
Section 25 90 00 Building Control Sequences.....	122
Section 26 00 00 Electrical Distribution.....	131
Section 26 05 00 Wiring and Cables	140

SECTION 01 00 00 PROJECT PROCEDURES

PART 1 GENERAL

1.1 WORK SUMMARY

- .1 The following is an overview of Work and is not complete. Contract Documents in their entirety fully describe Work, including items that may only be listed here. Work includes:
- .2 Scope Summary
 - .1 Demolish existing services as indicated.
 - .2 Modify heating water distribution system piping including relocating electric heating boiler and boiler pump.
 - .3 Provide 2 rooftop air handlers including structural design, structural reinforcement, roofing, curbs.
 - .4 Structural design is delegated to Contractor. Contractor to retain professional engineering.
 - .5 Provide fans including return fan, exhaust fan.
 - .6 Provide ductwork including diffusers, grilles.
 - .7 Provide electrical services as required.
 - .8 Provide building automation services including expansion of existing, modification of graphics, sequences, programming, trending.
 - .9 Perform air and hydronic testing and balancing.
 - .10 Provide fully functional systems that are complete and ready for intended use and effect.
- .3 Design Boundaries
 - .1 Existing zone air distribution, including VAV boxes and diffusers, are being reused except where critical to modify. Site reviews and testing during and after construction may identify some parts that require additional rework.
- .4 Work Considerations and Limitations
 - .1 Work may require use of particular means, methods, sequences, techniques, or procedures of construction not explicitly described in Contract Documents, which may require use of particular or specialty trades.
 - .2 Available space for new equipment and services is limited. Modify layouts, routing, mounting and existing services as required by Work.
 - .3 Disruption of any services for any duration requires advance notice and approval by Owner. Adhere to advance notice requirements stipulated by Owner.

1.2 DEFINITIONS AND ACRONYMS

- .1 Inclusiveness
 - .1 Specific words or terms including the following have been removed or replaced for brevity, the absence of which in no way limits the scope of the description:
 - .1 "All".
 - .2 "To" instead of "in accordance with".
 - .2 The word "including" or the word "includes" shall be taken to mean "including but not limited to".
 - .3 Lists of products, qualities, or responsibilities may be listed after inclusive statements for various purposes including for clarification, examples. The absence of list items shall not limit the inclusiveness of such statements.
- .2 Abbreviations, Acronyms, Names and Terms: Where acronyms, abbreviations, names and terms are used in Drawings, Specifications or other portions of Contract Documents, they shall mean the recognized name of the trade association, document generating organization or body, document publishing organization or body, authority having jurisdiction or other entity applicable.
 - .1 AABC: Associated Air Balance Council
 - .2 ACG: AABC Commissioning Group

- .3 AHRI: Air-Conditioning, Heating, and Refrigeration Institute (formerly Air-Conditioning and Refrigeration Institute)
- .4 AMCA: Air Movement and Control Association International, Inc.
- .5 ANSI: The American National Standards Institute, Inc.
- .6 ASC: The Adhesive and Sealant Council
- .7 ASHRAE: American Society of Heating, Refrigerating and Air-Conditioning Engineers
- .8 ASME: American Society of Mechanical Engineers
- .9 ASTM: American Society for Testing and Materials International
- .10 AWS: American Welding Society
- .11 BTL: BACnet Testing Laboratories, established by BACnet International
- .12 CAABC: Canadian Associated Air Balance Council
- .13 CGSB: Canadian Government Standards Board
- .14 CHC: The Canadian Hydronics Council
- .15 CRCA: Canadian Roofing Contractors' Association
- .16 CRCA: Chicago Roofing Contractors Association
- .17 CSA: Canadian Standards Association
- .18 CSC: Construction Specifications Canada
- .19 CWB: The Canadian Welding Bureau
- .20 ESA: Electrical Safety Authority (Ontario)
- .21 FCIA: Firestop Contractors International Association
- .22 IES: Illuminating Engineering Society (formerly Illuminating Engineering Society of North America)
- .23 ISO: The International Organization for Standardization
- .24 MICA: Midwest Insulation Contractors Association
- .25 NEBB: National Environmental Balancing Bureau
- .26 NECA: National Electrical Contractors Association
- .27 NEMA: National Electrical Manufacturers Association
- .28 NFPA: National Fire Protection Association
- .29 NIST: The National Institute of Standards and Technology
- .30 OIRCA: Ontario Industrial Roofing Contractors Association
- .31 OSMCA: Ontario Sheet Metal Contractors Association
- .32 PEO: Professional Engineers Ontario
- .33 SMACNA: Sheet Metal and Air Conditioning Contractors' National Association, Inc.
- .34 TIA: The Telecommunications Industry Association (formerly a part of the Electronic Industries Alliance)
- .35 TIAC: Thermal Insulation Association of Canada
- .36 UL: Underwriters Laboratories Inc.
- .37 ULC: Underwriters Laboratories of Canada
- .3 Words and terms used on Drawings and in Specifications are defined as follows:
 - .1 "Applicable": As appropriate for the particular condition, circumstance or situation.
 - .2 "Approve(d)": Approval action shall be limited to the duties and responsibilities of the party giving approval, as stated in Contract Documents. Approvals shall be valid only if obtained in writing and shall not apply to matters regarding the means, methods, techniques, sequences and procedures of construction. Approval shall not relieve Contractor from responsibility to fulfill requirements of Contract Documents. Where party giving approval is not indicated, approving party shall be Owner or Engineer.
 - .3 "Capability": Provide products as required including equipment and components ready for future configuration to make Work perform and/or operate as specified.
 - .4 "Code": Refer to "Regulation".
 - .5 "Concealed": Equipment, services and components that are not immediately exposed to view from a standing position on the normal walking path, including those that may be located behind doors, hatches, covers, access panels, inside enclosures, or in areas not easily accessible and visible without crouching, passing through spaces narrower than

- 24-in (61-cm), or using assistive devices not permanently mounted including ladders, lifts, illumination.
- .6 “Configure”: Complete activities required to meet performance or functionality requirements including initialization, jumper and dip switch setting, software parameter selection, programming, testing, commissioning, tuning and adjusting.
 - .7 “Consultant”: Same as “Consultant” as defined in Contract Documents; Otherwise the administrator of the Contract Documents.
 - .8 “Contract Documents”: Same as “Contract Documents” as defined in Contract Documents; Otherwise the documents which form the Contract.
 - .9 “Contractor”: Same as “Contractor” as defined in Contract Documents; Otherwise the entity named to complete Work including construction and related activities required to meet Contract Documents.
 - .10 “Crown”: The Crown in right of Canada and in right of all Canadian provinces.
 - .11 “Delegated Professional Design”: As described in this Section.
 - .12 “Directed”: Limited to duties and responsibilities of Owner or Engineer as stated in Contract Documents, meaning as instructed by Owner or Engineer, in writing, regarding matters other than the means, methods, techniques, sequences and procedures of construction. Terms such as “directed,” “requested,” “authorized,” “selected,” “approved,” “required,” and “permitted” mean “directed by Owner,” “directed by Engineer,” “requested by Owner,” and similar phrases. No implied meaning shall be interpreted to extend the responsibility of Owner, Engineer or other professional designers as indicated into Contractor’s supervision of construction.
 - .13 “Drawings”: The electronic version of that portion of Contract Documents, containing graphical and pictorial portions of Contract Documents, wherever located and whenever issued, showing the design, location, and dimensions of Work, generally including plans, elevations, sections, details, and diagrams.
 - .14 “Equal” or “Equivalent”: As determined by Engineer or other indicated responsible professional designer as being equivalent, considering such attributes as durability, finish, function, suitability, quality, utility, performance and aesthetic features.
 - .15 “Engineer”: Same as “Engineer” as defined in Contract Documents; Otherwise the designer of the technical documents.
 - .16 “Exposed”: Means not “concealed”.
 - .17 “Functionality”: Provide Work as required to be complete in every respect and fully functional, including installation, field finishing, configuration, and commissioning.
 - .18 “Furnish”: Supply and deliver to Site, ready for unloading, unpacking, assembly, installation, and similar operations.
 - .19 “Indicated”: Refers to graphic representations, notes, or schedules on Drawings, or other Paragraphs or Schedules in Specifications, and similar requirements in Contract Documents. Terms such as “shown,” “noted,” “scheduled,” and “specified” are used to help the reader locate the reference. There is no limitation on location of reference within Contract Documents.
 - .20 “Install”: Describes operations at Site including the actual unloading, unpacking, assembly, erection, placing, anchoring, applying, working to dimension, finishing, curing, protecting, cleaning, configuring and similar operations.
 - .21 “Installer”: The Contractor or an entity engaged by Contractor, including an employee, subcontractor or sub-subcontractor, for performance of a particular construction activity, including installation, erection, application and similar operations. Installers are required to be experienced in the operations they are engaged to perform.
 - .22 “Intent”: Refer to “Functionality”.
 - .23 “NIC”: Not In Contract. Indicates work completed or to be completed under separate contract.

- .24 “OFICI”: Owner Furnished Contractor Installed. Indicates materials, products or equipment to be provided under separate contract, and may include field finishing, configuration, and commissioning.
- .25 “Owner”: The entities that are the actual Owner, or the Owner's authorized agent or representative or other retained entities, and that have authority over the Site and Project.
- .26 “Products”: Same as “Product” as defined in Contract Documents; Otherwise materials including equipment and components forming Work.
- .27 “Project”: Construction and related services of which Work may be the whole or a part.
- .28 “Proper”: As determined by Engineer or other indicated responsible professional designer as being proper for Work, excluding matters regarding the means, methods, techniques, sequences and procedures of construction, which are solely Contractor’s responsibility to determine.
- .29 “Provide”: Furnish and install, complete and ready for the intended use and effect.
- .30 “Regulation”: Includes laws, statutes, regulations, orders, ordinances, codes, and standards issued or used by authorities having jurisdiction over Work. Includes federal, provincial and municipal governmental agencies, governing and local authorities, utilities, utility districts and other agencies serving the site. Includes rules, practices, conventions and agreements of authorities having jurisdiction and within the construction industry that control requirements and performance of Work.
- .31 “Regulatory”: As required by regulation.
- .32 “Required”: Necessary for performance of Work in conformance with requirements of Contract Documents including:
 - .1 Duties and responsibilities stated in the Bid Documents and Contract Documents.
 - .2 Requirements specified or referenced in the Specifications.
 - .3 Notes, schedules and graphic representations on the Drawings.
 - .4 Requirements of referenced documents.
 - .5 Regulatory requirements.
 - .6 Requirements generally recognized as accepted trade or industry practice.
- .33 “Requirements”: Aspects of Work that are required.
- .34 “Selected”: As selected by Owner, Engineer or other indicated responsible professional designer from the full selection of the manufacturer’s products, unless specifically limited in Contract Documents to a particular aspect, including quality, color, texture or price range.
- .35 “Site”: Same as “Site of Work” or “Project Site” or “Job Site”; the area or areas or spaces occupied by Project and including adjacent areas and other related areas occupied or used by Contractor for construction activities, either exclusively or with others performing other construction on Project.
- .36 “Specifications”: The electronic version of that portion of Contract Documents, wherever located and whenever issued, containing written requirements for Products, components, equipment, systems, activities, procedures, execution, and services required for performance of Work.
- .37 “Standby Power”: Electrical power generated on site and used during periods of utility power failure, whether or not the site generated power is used only during periods of utility power failure, and whether or not the site generated power is used for loads required to be supplied by emergency power.
- .38 “Statute”: Refer to “Regulation”.
- .39 “Statutory”: Same as “Regulatory” but for statutes.
- .40 “Supply”: Refer to “Furnish”.
- .41 “Work”: Refer to “Consultant” as defined in Contract Documents, otherwise Construction and related activities required to meet Contract Documents.
- .4 Names for manufacturers and products are defined in the following order:
 - .1 As determined by Engineer.

- .2 As generally recognized by construction industry practice.
- .5 Words, terms, abbreviations, measurement units not otherwise specifically defined in this Section or in Contract Documents are defined in the following order:
 - .1 As determined by Engineer when a conflict exists between any of the following.
 - .2 As described by regulation.
 - .3 As described by referenced documents.
 - .4 As described in specialty dictionaries in the following order:
 - .1 Dictionary of Architecture and Construction, Latest Edition (Cyril M. Harris, McGraw-Hill Professional).
 - .2 Encyclopedia of Associations, online directory by Thomson Gale, accessible through many public libraries.
 - .5 As determined by Engineer. Input may be provided by Contractor on definitions based on the following in the following order:
 - .1 As generally recognized by construction industry practice.
 - .2 As generally recognized by trade practice.

1.3 MULTIPLE CONTRACT SUMMARY

- .1 Other Current Contracts
 - .1 Owner has other ongoing or concurrent separate contracts including:
 - .1 Maintenance, repairs and service.
 - .2 Coordinate and cooperate with other contractors responsible for project health and safety in compliance with the Occupational Health and Safety Act.
 - .3 Regularly meet with other contractors, and coordinate activities with other contractors as required.
 - .2 Other Products
 - .1 All products indicated shall be considered to be fully part of Work unless otherwise denoted by NIC (Not in Contract) or OFCI (Owner Furnished Contractor Installed).

1.4 PROJECT ADMINISTRATION

- .1 Submittals and Transmittals
 - .1 Format: Provide submittals and transmittals in electronic format unless otherwise indicated.
 - .1 Electronic Format
 - .1 Transmit to recipients' e-mail addresses, or alternate means for large electronic file submissions.
 - .2 Transmit photographs in JPG format acceptable to Engineer, including resolution, focus and light levels.
 - .3 Transmit other submittals in file formats as indicated. Where file formats are not indicated, use Adobe PDF format acceptable to Engineer, including clarity, alignment, unsecured, provided with original PDF source files where available, converted to PDF with original source files. Unacceptable: Scans of other formats where PDF file can be provided or converted from original source files.
 - .4 File Naming: Name electronic files appropriately and consistently. Electronic file naming convention subject to review and approval by Engineer.
 - .5 Multiple Electronic File Submission: Maintain separate subject matter in separate electronic files.
 - .2 Paper Format
 - .1 Transmit to recipients at recipients' business addresses.
 - .2 Transmit in paper format acceptable to Engineer, including size, colour, clarity and alignment.
 - .2 Recipients: As required.
 - .3 Response: Allow 10 working days for responses from Engineer unless otherwise indicated.

- .2 Project Meetings: Conduct project meetings at Owner's preferred location at 1-week intervals.
 - .1 Attendees: Owner, Engineer, Contractor, and project stakeholders as defined by Owner.
 - .2 Coordination: Inform individuals whose presence is required of date and time of each meeting, including Contractor staff, subcontractors and suppliers. Inform individuals whose presence may not specifically be required but are involved of the project of date and time of each meeting to be available by phone during the meeting, including Contractor staff, subcontractors and suppliers. Notify Owner and Engineer of arranged meeting dates and times. Provide 2-week notification.
 - .3 Agenda: Prepare meeting agenda. Distribute meeting agenda not less than 2 working days before the meeting to invited attendees.
 - .4 Minutes: Prepare meeting minutes. Distribute meeting minutes within 2 working days of meeting to invited attendees and appropriate stakeholders as determined by Owner. Include the following information:
 - .1 Attendance.
 - .2 Discussions.
 - .3 Agreements.
 - .4 Action items in a separate list, including responsible parties and individuals, and required completion dates.
 - .5 Modifications: Owner may modify project meeting requirements, including Engineer to take responsibility for project meeting minutes, at no change to Contract Price or Contract Time.
- .3 Progress Meetings: Conduct progress meetings at Contractor's preferred location at 1-week intervals.
 - .1 Attendees: Contractor personnel familiar with or required to be familiar with Work and authorized to conclude matters relating to Work.
 - .2 Agenda
 - .1 Review and approve minutes of previous progress meeting, including modifications to minutes.
 - .2 Review other items of significance that could affect progress. Include topics for discussion as appropriate to status of Work.
 - .3 Review progress since last meeting. Determine whether each activity is on time, ahead of schedule, or behind schedule in relation to Contractor's construction schedule.
 - .4 Determine how construction schedule will be expedited.
 - .5 Secure commitments from parties involved to do so.
 - .6 Discuss whether construction schedule revisions are required to ensure that current and subsequent activities will be completed within Contract Time.
 - .3 Schedule
 - .1 Updates: Update construction schedule after each progress meeting where revisions to construction schedule have been made or recognized.
 - .2 Distribution
 - .1 Submit updated construction schedule in colour ledger sized paper format concurrently with each progress meeting report.
 - .2 Transmit updated construction schedule in electronic format to Engineer.
 - .3 Revisions: Review and evaluate construction schedule regularly during construction. Revise construction schedule as necessary as a result of review, and resubmit within 2 working days.
 - .4 Format: Software generated Gantt chart as acceptable to Engineer including for ease of use of data.
 - .1 File Type: Microsoft Project and Adobe PDF of file.
 - .4 Reporting: Provide brief narrative progress report to define problem areas, potential yet not yet claimed clarifications and substitutions and changes, concealed work, anticipated

- delays, and impact on the construction schedule. Report actions taken or proposed, and its effect including impacts on separate contracts. Identify modifications since previous submittal, including activities and changes.
- .5 Distribution
 - .1 Distribute reports and construction schedules within 2 working days of the meeting.
 - .2 Distribute to Contractor's site file, to subcontractors, suppliers, Engineer, Owner, and other concerned parties.
 - .3 Instruct recipients to promptly report, in writing, problems anticipated by projections shown in schedules.
 - .4 Progress Completed Reporting: Conduct progress completed updates at Site at end of each working shift.
 - .1 Attendees: Owner, Contractor, and project stakeholders as defined by Owner.
 - .2 Agenda
 - .1 Review Work completed, which affected systems and areas are ready for use, which affected systems and areas are not fully operational.
 - .2 Discuss whether interim operating procedures are requested of Owner.
 - .3 Reporting: Provide verbal or written or both verbal and written summary as required by Owner.
 - .5 Progress Planned Reporting: Conduct progress planned updates at Site at beginning of each working day.
 - .1 Attendees: Owner, Contractor, and project stakeholders as defined by Owner.
 - .2 Agenda
 - .1 Review Work planned, which systems and areas will be affected, which other systems and areas may be affected.
 - .2 Discuss whether interim operating procedures are requested of Owner.
 - .3 Reporting: Provide verbal or written or both verbal and written summary as required by Owner.
 - .6 Other Meetings: Adhere to project meeting procedures for other meetings.

1.5 CASH ALLOWANCES EXTENT AND PROCEDURES

- .1 Work Included in Cash Allowance Amounts
 - .1 Work described under this Article except as follows.
 - .1 Contractor costs related to Work performed under Cash Allowances include Contractor overhead, profit, management, supervision, coordination, administration. Such costs are to be included in Bid Price outside of Cash Allowance amounts.
 - .2 Work described under this Article is separate and additional to Work described elsewhere in Contract Documents except as specifically indicated in this Article.
- .2 Description of Work
 - .1 Hazardous Materials Abatement
 - .1 Service Provider: As determined by Owner.
 - .2 Scope: Abatement of known or suspected hazardous materials.
 - .2 Building Automation System
 - .1 Service Provider: HTS Engineering Inc.
 - .1 Address: 110 Lancing Drive, Building 1, Suite 3, Hamilton, Ontario L8W 3A1
 - .2 Contact: N: Plamen Yordanov, T: (855) 840-5105, F: (905) 308-9573, M: (905) 971-5167, E: greg.asada@trane.com
 - .2 Scope
 - .1 Provide building automation services including expansion of existing, control devices, modification of graphics, sequences, programming, trending.
 - .2 Training activities required by BAS service provider, as indicated in Article 1.25 Training Requirements of this Section.

- .3 Scheduling: Complete site reviews and investigations within 14-days after contract award.
- .4 Pricing of Work
 - .1 Owner reserves right to obtain themselves, or have Contractor obtain a single or multiple competitive quotations from potential subcontractors or suppliers for Work that is to be paid from Cash Allowance(s). In addition to the following, provide Owner with 7-days notification to allow Owner to decide on pricing approach.
 - .2 Where quotation(s) are obtained by Contractor:
 - .1 Ensure quotation(s) include reference to project Contract Documents, and cover complete scope of Work for the Cash Allowance(s) described in Contract Documents.
 - .2 Obtain and submit quotation(s) within 14-days of instruction to obtain pricing for Work under Cash Allowance.
 - .3 Quantity of quotations required to be obtained is 3, or less as required by Owner.
 - .3 Submit quotation(s) to Engineer for authorization under Cash Allowance authorization procedures.
- .5 Authorization to Proceed: Contractor shall not proceed with Work under Cash Allowance without written authorization. Submittal reviews are not considered authorization to proceed under Cash Allowance provisions.

1.6 PAYMENT PROCEDURES

- .1 Schedule of Values: Provide schedule of values at least 15-days prior to first application for payment. Provide detailed schedule of values including:
 - .1 Investigation, submittal, and mobilization costs.
 - .2 Separate equipment material cost, and quantities for each equipment type.
 - .3 Separate installation cost for major equipment.
 - .4 Separate installation cost for each system.
 - .5 Separate costs for balancing, start-up and system testing.
 - .6 Individual itemized cash allowance amounts.
 - .7 Commissioning costs.
 - .8 Close-out costs.

1.7 ADDITIONAL REGULATORY REQUIREMENTS

- .1 Crown Prerogative: Should Crown prerogative be applicable to Work, including statutes that may not bind the Crown, adhere to all laws as if Crown prerogative was not applicable and as if the Crown were bound by all statutes.
- .2 Edition Dates: The edition date of applicable laws, regulations, orders and ordinances shall be that of the date of performance of Work. The edition date of applicable codes, standards and practices shall be that adopted at the time of issuance of documents or approvals by authorities having jurisdiction, and shall include modifications, additions and interpretations adopted by that jurisdiction.
- .3 Precedence
 - .1 Where specified requirements differ from the requirements of applicable regulation, the more stringent requirements shall take precedence.
 - .2 Where Drawings or Specifications require or describe products or execution of better quality, higher standard or greater size than required by applicable laws, regulations, orders, and ordinances, Drawings and Specifications shall take precedence so long as such increase is legal.
 - .3 Where no requirements are identified in Drawings or Specifications, comply with requirements of regulation.
- .4 Permits
 - .1 Obtaining: Obtain approvals for the Work including preparing, submitting, processing and obtaining approval. Approvals may include permits, certificates, licenses.
 - .1 Include the following, which may include items to complete on behalf of Owner:
 - .1 Electrical permits.
 - .2 As required.

- .2 Exclude the following, which may be obtained by others:
 - .1 Building permits.
 - .2 Operating Engineers plant registration.
- .2 Reviews, Tests, and Inspections
 - .1 Despite which entity obtained approvals listed above, make arrangements for and ensure completion of reviews, tests, and inspections by authorities having jurisdiction including serving utilities, regardless if Owner or others solely have the responsibility to communicate with authorities having jurisdiction and serving utilities over specific matters. Owner and Engineer may inform Contractor of same. Notify Owner and Engineer of reviews, tests, inspections, or other site activities by authorities having jurisdiction minimum 48 hours prior to activities taking place.
 - .2 Includes reviews, tests, and inspections that may be required to be completed, or voluntary requested by Contractor, Owner, Engineer.
 - .3 Upon approval from Owner, arrange for reviews, tests, and inspections, and coordinate dates and times acceptable to Owner and Engineer.
 - .4 Participate in and be present during reviews, tests, and inspections, and as well as additional follow-up reviews, tests, and inspections.

1.8 REFERENCES

- .1 Referenced Documents: Drawings and Specifications contain various references, including to various codes, standards, practices and requirements. Such references are used for various purposes, including for products, execution, tests and inspections.
- .2 Relationship to Drawings and Specifications: Referenced documents in Drawings and Specifications are made a part of Drawings and Specifications, and have the full force and effect as though printed in their entirety in Specifications, including design and installation requirements.
 - .1 Where referenced documents are indicated, requirements within referenced documents are fully applicable to Work regardless of whether such referenced documents or portions of them may otherwise be exempt from applicability to Work.
 - .2 Where referenced documents are indicated, including in a referenced documents list, adhere to requirements of referenced documents in their entirety including installation and design requirements, whether or not use of referenced documents is specifically identified elsewhere.
 - .3 Details and choices related to layouts, sizing and ratings are to be included with submittals.
- .3 Completeness: Referenced documents include, whether specifically referred to or not, addenda, errata, interpretations, supplements, handbooks and guidelines as issued or used by:
 - .1 Referenced document issuing body(s).
 - .2 Authority(s) having jurisdiction(s).
- .4 References Within References: Referenced documents include additional references to other reference documents. Adhere to requirements of these other referenced documents in their entirety to the extent applicable, including installation and design requirements. Details and choices related to layouts, sizing and ratings are to be included with submittals.
- .5 Convenience: Specific references are for convenience only and do not limit completeness, including:
 - .1 Referencing Other Specification Sections: Specification Sections may contain referencers to other Specification Sections. Such references are made notwithstanding the specific inclusiveness of each Specification Section.
 - .2 Related Referenced Documents: References may include additional references to related documents, including addenda, errata, interpretations, supplements, handbooks and guidelines.

- .6 Copies: Referenced documents are not furnished with Drawings and Specifications as it is presumed that Contractor, subcontractors, manufacturers, suppliers, trades and crafts are familiar with these generally recognized standards of the construction industry.
- .7 Names: In the event a referenced document is no longer available or recognized, reference shall be understood to be either:
 - .1 Latest edition of replacement reference from same publishing organization or body.
 - .2 Latest edition of replacement reference from replacement publishing organization or body.
- .8 Edition Dates
 - .1 Where an edition or effective date of a referenced document is given, it shall be understood to be the more stringent of:
 - .1 As indicated.
 - .2 Latest edition adopted by authorities having jurisdiction.
 - .2 Where an edition or effective date of a referenced document is not given, it shall be understood to be the more stringent of:
 - .1 Latest edition adopted by authorities having jurisdiction.
 - .2 Latest edition published at time of issuance of permits, certificates, licenses, or approvals by authorities having jurisdiction.
 - .3 Latest edition published at time of execution of Contract Documents, whether or not reference has been adopted by authorities having jurisdiction.
 - .3 Previous Edition Related Referenced Documents: Related reference documents from previous editions of references are to be used in the absence of updates to related documents with indicated reference edition.
- .9 Referenced Grades Classes and Types: Where an alternative or optional grade, class or type of product or execution is included in a reference but is not identified on Drawings or in Specifications, provide the highest, best and greatest of the alternatives or options for the intended use and prevailing conditions.
- .10 Conflicting Requirements: Where compliance with 2 or more references are specified, or requirements from 2 or more references and/or related reference documents are present, and these references establish different or conflicting requirements for minimum quantities or quality levels, comply with the most stringent requirement. Refer uncertainties and requirements that are different, but apparently equal, to decision by Engineer before proceeding.

1.9 DESIGN DOCUMENTS CONTENT

- .1 Means and Methods
 - .1 Intent of Drawings and Specifications are to describe design intent including scope and quality of Work in a finished state. Contractor is solely responsible for all means, methods, sequences, techniques, and procedures of construction to complete Work as so described.
 - .2 Should Drawings and Specifications indicate specific means, methods, sequences, techniques, and procedures of construction, such specifics are for the purposes of minimum quality in completing the Work to a finished state.
- .2 Warnings and Specific Limitations
 - .1 Should Drawings and Specifications indicate certain types of warnings and specific limitations, such specifics in no way imply authorization of Work that otherwise does not meet requirements of Contract Documents when such warnings and statements are not made elsewhere, including:
 - .1 Convenience Warnings: Cautionary notes or warnings or specific limitations are made for the purposes of convenience. Such warnings may include drawing Contractor's attention to matters regarding means, methods, sequences, techniques, and procedures of construction.
 - .2 Prohibited Work: Statements on specific prohibited work are made for the purposes of highlighting specific limitations.

- .3 Inconsistencies
 - .1 Contractor shall report to Engineer immediately when mistakes are found in Drawings and Specifications, if design intent is unclear, or if elements essential to proper execution of Work are discovered to be missing.
 - .1 Should an essential element be discovered as missing or mistakes are found prior to receipt of Bids, an Addendum will be issued so that costs may be accounted for in Contract Price.
 - .2 Should an obvious omission or obvious mistake describing a necessary element be discovered and reported after execution of the Agreement, Contractor shall provide the element as though fully and correctly described, and a no-cost Instruction or Change Order shall be executed.
 - .3 Refer to related general requirements regarding construction interfacing and coordination.
 - .2 In case of inconsistency(s) between or within Drawings and Specifications, provide the following unless interpreted otherwise by Engineer:
 - .1 For differences in indicated quality, adhere to better quality of Work.
 - .2 For differences in indicated quantity, adhere to greater quantity of Work.
 - .3 For other differences, adhere to the more stringent requirement as determined by Engineer.

1.10 ADDITIONAL TECHNICAL INFORMATION

- .1 The following information is not necessarily provided with Contract Documents, but is to be reviewed by Contractor as part of Contract Documents:
 - .1 Site Information: The following information is available or can be made available on site upon request:
 - .1 Building drawings.
 - .2 Supplemental project and renovation drawings.
 - .3 Asbestos reports.
 - .4 Hazardous materials reports.
 - .5 Operating and maintenance manuals.
 - .6 Other reports and plans.
 - .2 Specification Information: The following information will be available for review at Engineer's business address with reasonable notice:
 - .1 Referenced documents.
 - .2 Owner CAD standards and guideline documents.
 - .3 Other Owner requirements documents.

1.11 SUBMITTAL PROCEDURES

- .1 Provide submittals as indicated. Required submittals may only be described in submittals articles of each Section, and may not be further described in products or execution articles of each Section.
- .2 Submittals For Action
 - .1 Submit as indicated to Engineer and Owner for review. Reviews shall be for the limited purpose of reviewing general conformance with the design concept expressed in Contract Documents. Submittal comments or lack thereof in no way relieve Contractor's responsibility for meeting all requirements of Contract Documents.
 - .2 It is Contractor's sole responsibility to ensure that submittals are timely, complete and comprehensive.
 - .3 Engineer may not review information provided if such information is incomplete or not comprehensive.
 - .4 Engineer may comment on incomplete or missing submittals.
 - .5 Engineer may provide commentary, notes or warnings on review of submittal. Contractor shall carefully read submittal review, complete investigations as required to address submittal review contents, and re-submit submittal prior to ordering products or proceeding.

- .6 In the event Work requiring submittal for action has been completed without Engineer's written review, modify Work as required, including as indicated by Engineer, with no changes to Contract Price or Contract Time.
- .3 Submittals For Information
 - .1 Submit as indicated to Engineer and Owner on behalf of Commissioning Authority and/or Owner. No review action will be taken by Engineer.
- .4 Submittals For Closeout
 - .1 Submit as indicated to Engineer and Owner on behalf of Commissioning Authority and/or Owner. No review action will be taken by Engineer.
- .5 Other Submittals
 - .1 Submit other submittals as indicated to Engineer and Owner.
- .6 Submission
 - .1 Transmit each submittal with a letter of transmittal as acceptable to Engineer.
 - .2 Schedule submittals to expedite Work and coordinate submission of related items.
- .7 Content: Identify relevant and required information, including:
 - .1 Project name.
 - .2 Entities related to Work, including Contractor, subcontractor and supplier, as applicable.
 - .3 Pertinent Drawing and detail number, and Specification Section and Title, as appropriate.
 - .4 Bill of materials for products or system features included in submittal. Bill of materials to include tag, description, quantities, makes, and model numbers or part to be ordered. Model numbers to be complete, including selected features and options, special instructions or custom aspects. Provide notes to describe special instructions or custom aspects, as well as notes on who is responsible and where to provide, i.e. at factory by manufacturer or in field by Contractor. Indicate selected features and options on each submittal page or product sheet by using annotation boxes or highlights.
 - .5 Confirmation of investigations having been completed and verification of suitable application for successful performance of completed Work.
 - .6 Variations from Contract Documents.
 - .7 Extent of impacts on requirements due to variations from Contract Documents, including performance requirements.
 - .8 Product or system limitations that may be detrimental to successful performance of completed Work.
 - .9 Custom fabrications or assemblies that may require professional engineering services.
 - .10 Changes made since previous submission.
- .8 Apply Contractor's stamp to submittal documents stating submittal has been reviewed, complete with review date and reviewer name. Contractor stamp applied to submittal documents certifies Contractor investigations have been completed, including verification that product characteristics, field dimensions, adjacent construction Work, and coordination of information are in accordance with requirements of Work and Contract Documents.
- .9 Format: Transmit submittals in electronic format unless otherwise indicated.
- .10 Quantity: Unless otherwise indicated, submit 4 copies of submittals in paper format when printed or paper format is indicated.
- .11 Distribution: Engineer will transmit reviewed submittals with further action as required to Contractor and others at Engineer's discretion. Submittals with completed review actions shall be distributed by Contractor as appropriate.
- .12 Modifications: Engineer may at Engineer's discretion choose to:
 - .1 Review an incomplete submittal.
 - .2 Designate a transmittal as a request for substitution or Change Proposal.
 - .3 Designate a transmittal as a request for clarification.

- .4 Review submittals for information or submittals for closeout.
- .5 Change the submittal type, such as a submittal for information into a submittal for action.

1.12 PRODUCT REQUIREMENTS

- .1 Selection: Provide products that are new, unused, undamaged.
- .2 Ratings: Provide products that are rated for the conditions to which they will be subjected, including typical operation and potential extremes.
- .3 Required Products: Provide products of types and kinds that meet regulatory requirements and standards including provisions of local building code. Various product requirements apply, including:
 - .1 Combustible Materials: Provide products as indicated and that meet local building code, including to provisions of local building code even should local building code not apply, including where building is or is required to be of noncombustible construction to local building code, including:
 - .1 Noncombustible materials.
 - .2 Minor combustible components as specifically described. Provide submittals to Engineer on materials that may be defined as “similar minor components”.
 - .3 Combustible materials and components and their application where specifically described.
 - .2 Fire Resistance Ratings: Where materials and assemblies do or are required to have fire resistance ratings, provide products as indicated and that meet local building code, including to provisions of local building code even should local building code not apply, including:
 - .1 Determination of ratings and minimum ratings.
 - .2 Exceptions and exposure conditions of ratings.
- .4 Standard Products: Where specific products are not specified or required by regulation, provide standard products of types and kinds that are suitable for intended purposes, use and effect, and that are usually and customarily used on similar projects under similar conditions. Products shall be subject to review and acceptance by Engineer.
- .5 Completeness: Provide products complete with details and configuration needed for a complete installation and for intended purposes, use and effect, including accessories, trim, finish, safety guards, structural supports, platforms, braces, tie-rods, and other devices. Provide products with services and components connections of type(s) and configuration required to match the requirements for mating services and components.
- .6 Service Connections: Coordinate requirements and types of connections to services and components by matching requirements for such services and components as indicated throughout Drawings and Specifications, or as required where not indicated.
- .7 Consistency: Provide products of the same kind from the same manufacturer and from a single source over duration of Work. Provide specified product options from same manufacturer as product and native to product to the fullest extent possible.
- .8 Visual Matching: Where sample matching is required, the decision by Engineer on whether a proposed product matches shall be final. Where no product visually matches but the product complies with other requirements, comply with provisions for substitutions for selection of a matching product in another category.
- .9 Configuration and Settings: Maintain configured settings on loss of power or communications, minimum 72-hours unless otherwise indicated. Record settings used.
- .10 Product Features: Product features specifically indicated or otherwise required may require custom configuration and customization from manufacturer, even for products where a specific manufacturer and/or product line is specified.
- .11 Options Selection: Where requirements include the phrase “as selected from manufacturer’s standard colours, patterns and textures” or a similar phrase relating to options as well as features, selections of products will be made by indicated party or, if not indicated, by

- Engineer. Engineer will select options from the product line of submitted manufacturer if all other specified provisions are met.
- .12 Products, Assemblies and/or Systems Assemblies Specified by Performance and/or Future Requirements: Where Specifications require compliance with performance or future requirements, including intent, functionality, or capability, select products and design assemblies and/or systems to meet specified requirements, provide and revise submittals to satisfaction of Engineer, and demonstrate requirements met upon request to satisfaction of Engineer.
 - .13 Specification Methods
 - .1 By Name: Where Specifications describe one or more manufacturer names, brand names or model numbers, provide a product to meet these requirements.
 - .2 By Description: Where Specifications describe a product, listing characteristics required, with or without use of a manufacturer name or brand name, provide a product to meet these requirements as determined by Engineer, including operational characteristics, performance attributes, quality, serviceability, and other relevant characteristics.
 - .3 By Performance Requirements or Intent: Where Specifications require compliance with performance requirements, intent, or functionality, provide product(s) and/or assemblies that comply and are recommended by the manufacturer for the intended application. Verification of manufacturer's recommendations may be by product literature or by certification of performance from manufacturer.
 - .4 By Referenced Documents: Where Specifications require compliance with a referenced document including standards, provided product shall fully comply with the referenced document.
 - .5 By Combination of Methods: Where products are specified by a combination of attributes, including manufacturer's name, product brand name, product catalogue or identification number, industry standards, referenced documents, or description of product characteristics, provide products conforming to specified attributes.

1.13 EXECUTION REQUIREMENTS

- .1 Acceptance of Conditions
 - .1 Examine existing conditions, surfaces and substrata upon which Work depends.
 - .2 Drawings are diagrammatic and intended to convey scope of Work and indicate general and approximate location, arrangement and sizes of equipment and services including piping, ductwork, venting, and wiring.
 - .3 Obtain more accurate information about locations, arrangement and sizes from:
 - .1 Site inspection and measurement.
 - .2 Study and coordination of existing building drawings including base building drawings and supplemental project and renovation drawings, existing equipment and systems shop drawings, and manufacturers' literature.
- .2 Means, Methods, Sequences, Techniques, and Procedures of Construction
 - .1 Engage a professional engineer under Delegated Professional Design to provide design documents on Work related to means, methods, sequences, techniques, and procedures of construction, including:
 - .1 Temporary structures including shoring, bracing, hoarding, underpinning, and scaffolding.
 - .2 Hoisting and rigging activities.
 - .3 Modifications or alterations to surfaces or structures, including doorways, walls, floors, ceilings, roofs.
 - .4 As required by regulation and Owner policies, including matters related to health and safety.
- .3 Preparation
 - .1 Determine exact location and routes for Work including equipment and services.
 - .2 Relocation

- .1 Modify routing and/or relocate equipment and services as required.
- .2 Relocate existing equipment and services as required, including piping, ductwork, venting, electrical, controls, fire protection including sprinklers and detection.
- .3 Demolition and Removal
 - .1 Remove existing equipment and services as indicated.
 - .2 Remove existing and obsolete equipment and services to satisfaction of Owner within affected areas including:
 - .1 Equipment and services affected by Work, including interference and components modified by Work.
 - .2 Equipment and services not affected by Work.
 - .3 As indicated including markings on site.
 - .3 Relocate existing equipment and services that interfere with Work.
 - .4 Refrain from cutting by dismantling whenever possible. If cutting is required, submit Demolition Plan for review before cutting.
 - .5 Create or enlarge openings in surfaces or structures, including doorways, walls, floors, ceilings, roofs, as required to permit installation of equipment and services, and reinstate as required.
 - .6 Patch openings, and refinish surfaces including walls where parts are removed or relocated.
 - .1 Subject to Owner approval, openings in occupiable spaces with special finished surfaces that are not practical to match may be covered by plates matching existing décor. Covering plate material and finish subject to Owner approval.
- .4 Digging and Excavation
 - .1 Refrain from pumping waste, dirt, or suspended materials into waterways, sewer, or drainage systems without prior treatment.
 - .2 Dust Control: Cover or wet down dry materials and rubbish to prevent blowing dust at all times.
 - .3 Protect trees and plants from damage.
 - .1 Regularly water trees and plants under stress from construction activities.
 - .2 Wrap trees and plants, and construct temporary mechanical protection as required.
 - .3 Protect roots from damage from excavation activities, and soil compaction.
 - .4 Replace trees and plants damaged by construction activities.
- .5 Transportation, Delivery and Handling
 - .1 Comply with manufacturer's instructions and recommendations.
 - .2 Provide all equipment and personnel as required.
 - .3 Coordinate with Owner for delivery and acceptance.
 - .4 Schedule delivery to minimize long-term storage and prevent overcrowding construction spaces. Coordinate with installation to ensure minimum holding time for items that are flammable, hazardous, easily damaged or sensitive to deterioration, theft and other losses.
- .6 Storage
 - .1 Provide temporary off site storage for products until ready for installation. Temporary on site storage is prohibited unless approved by Owner.
 - .2 Store and protect products in accordance with manufacturers' instructions, with seals and labels intact and legible.
 - .3 Store sensitive products in weather-tight enclosures or covered with an impervious sheet covering. Provide adequate ventilation, temperature and humidity control to avoid condensation, corrosion and damage due to temperature and humidity limits.
 - .4 Periodically inspect storage areas to ensure that products are undamaged and are maintained under required conditions.
 - .5 Products damaged by improper storage or protection shall be removed and replaced with new products, with no changes to Contract Price or Contract Time.

- .7 Products, Assemblies and/or Systems Assemblies Specified by Performance and/or Future Requirements: Where Specifications require compliance with performance or future requirements, including intent, functionality, or capability, select products and design assemblies and/or systems to meet specified requirements, provide and revise submittals to satisfaction of Engineer, and demonstrate requirements met upon request to satisfaction of Engineer.
- .8 Installation of Products
 - .1 Comply with manufacturer's instructions and recommendations for installation of products, except where more stringent requirements are specified, are necessary due to Work, or are required by authorities having jurisdiction.
 - .2 Anchor each product securely in place, accurately located and aligned with other Work.
 - .3 Clean exposed surfaces and provide protection to ensure freedom from damage and deterioration.
 - .4 Provide sufficient clearance for servicing and maintenance access.
 - .5 Protect installed products from damage during construction, including surface marring, vibration and dust. Provide protective wrappings as required.
- .9 Cleaning
 - .1 Conduct cleaning operations as required, including Owner requirements, applicable laws, regulations, orders and ordinances, codes, standards, and practices, including waste management and environmental protection laws.
 - .2 Clean areas, equipment, fixtures, surfaces, and products affected by construction including:
 - .1 Parking areas, sidewalks, driveways and streets.
 - .2 Metal surfaces.
 - .3 Floor surfaces.
 - .4 Horizontal and vertical surfaces.
 - .5 Lighting fixtures.
 - .6 Glass and mirrors.
 - .7 Exterior grounds and gardens.
 - .8 Metalwork: Clean and buff metalwork to be free of soiling and fingerprints. Mirror finished metal work shall be buffed to high lustre.
 - .3 Building Exterior Cleaning: Clean surfaces in existing and adjacent buildings where construction activities have caused soiling and migration and accumulation of dust and debris.
 - .1 Wash down exterior surfaces to remove dust.
 - .2 Clean exterior surfaces of mud and other soiling.
 - .3 Clean exterior side of windows, including window framing.
 - .4 Ventilation System Cleaning: Replace filters and clean heating and ventilating equipment used for temporary heating, cooling and ventilation.
 - .5 Cleaning Frequency
 - .1 Minimum daily and more frequently as required for the following:
 - .1 Occupiable and visible areas.
 - .2 Minimum weekly and more frequently as required for remaining areas.
 - .6 Cleaning Agents and Materials
 - .1 Non hazardous to health or property.
 - .2 Use cleaning materials only on surfaces recommended by cleaning agent manufacturer.
 - .3 Use only those cleaning agents, materials and methods recommended by manufacturer of the material to be cleaned.
 - .7 Contract Completion Review Cleaning: Execute a thorough cleaning prior to Contract Completion review. Complete final cleaning before submitting final Application for Payment.
- .10 Reinstatement

- .1 Reinstall systems and components that may have been modified or relocated due to Work to satisfaction of Owner and Engineer.
- .2 In addition, reinstall the following areas and with indicated frequency:
 - .1 Minimum daily and more frequently as required for the following:
 - .1 Occupied and visible areas.
 - .2 As required for remaining areas to not interfere with building operations.
- .11 Waste Removal
 - .1 Conduct disposal operations as required, including Owner requirements, applicable laws, regulations, orders and ordinances, codes, standards, practices, waste management laws, and environmental protection laws.
 - .2 Provide waste removal facilities and services as required to maintain the site and existing facilities in clean and orderly condition.
 - .3 Provide containers with lids. Dispose of waste off-site periodically.
 - .4 Open free-fall chutes are not permitted. Terminate closed chutes into appropriate containers with lids.
- .12 Waste Management
 - .1 Separate and dispose of construction waste as required and in compliance with Owner requirements, applicable laws, regulations, orders and ordinances, codes, standards, and practices, including waste management and environmental protection laws.
- .13 Reviews, Tests, and Inspections
 - .1 Inform Owner of scheduled reviews, tests, and inspections required, regardless if Owner solely has responsibility to communicate with other entities over specific matters. Owner and Engineer may inform Contractor of same.
 - .2 Includes reviews, tests, and inspections that may be required to be completed, or voluntary requested by Contractor, Owner, Engineer.
 - .3 Upon approval from Owner, arrange for reviews, tests, and inspections, and coordinate dates and times acceptable to Owner and Engineer.
 - .4 Participate in and be present during reviews, tests, and inspections, as well as additional follow-up reviews, tests, and inspections.
- .14 Handover
 - .1 Operational Responsibility
 - .1 For systems, equipment, and components affected by Work, Contractor's operational responsibility includes all responsibilities that would otherwise fall to Owner, including operation to be to the safe, reliable, performing to expectations. Contractor responsibilities include coordination with Owner regarding operational requirements. Operational responsibility for new or existing affected systems, equipment, or components, remains with Contractor until such responsibility is transferred to Owner.
 - .2 Transfer of Operational Responsibility
 - .1 When Contractor has achieved a level of completion appropriate for transferring operational responsibility to Owner, Contractor shall:
 - .1 Provide written notice that Contractor intends on transferring operational responsibility to Owner, including clear indication of which specific aspects of Work are covered by the notice.
 - .2 Provide Owner with a detailed list of any outstanding items of Work related to the equipment or systems being transferred to Owner's responsibility.
 - .3 Provide a date and time acceptable to Owner for when the transfer of responsibility is to become effective. Such date shall not be less than 7-days nor more than 31-days from the date the notice is provided to Owner.
 - .4 Provide confirmation acceptable to Owner that required training, documentation, regulatory approvals, functional testing, and commissioning have been completed and submitted to Owner as required.

- .2 Should Owner choose to waive any such requirements for the purpose of interim operations, Contractor is not relieved of the responsibility for meeting such requirements at a later date.
- .3 Demonstration of Interim Operation
 - .1 Based on Owner's discretion of completion level, including completion of specific areas or elements of Work, when Contractor has achieved a level of completion appropriate for demonstration to Owner for the purpose of operation by Owner, Contractor shall:
 - .1 Provide to Owner a summary of Work completed.
 - .2 Show Owner Work completed.
 - .3 Provide to Owner required training and documentation necessary for Owner to operate in the interim until final training is provided.
 - .4 Review and document logging and reporting requirements of Owner during interim operation.
 - .2 Should Owner choose to waive any such requirements for the purpose of interim operations, Contractor is not relieved of the responsibility for meeting such requirements at a later date.

1.14 SUBSTITUTION PROCEDURES

- .1 Request for Substitution (RFS): A written request submitted by Contractor to deviate from specified product requirements.
- .2 RFSs are only to be submitted after Contractor has completed thorough investigations and planning to incorporate substitution into Work to achieve full use and effect.
- .3 RFSs will only be considered when submitted in sufficient time to permit review by Engineer.
- .4 RFSs to include differences between specified requirements and substitution, including the following:
 - .1 Clear title denoting the document as a "Request for Substitution".
 - .2 Reason for requesting substitution that is justifiable to Engineer.
 - .3 A summarized comparison of physical properties and performance characteristics for specified requirements and substitution, and clearly highlighting variations.
 - .4 Indication of reductions to contract costs and dates.
 - .5 Verification that substitution will not result in additional costs or a reduction in performance to other portions of Work.
 - .6 Additional information for products including:
 - .1 Identification, including manufacturer's name, address, telephone and fax numbers, and web site address where available.
 - .2 Manufacturer's data sheets, including material descriptions, compliance with regulation and referenced documents and applicable standards, performance and test data.
 - .3 Indication of availability of maintenance services and sources of replacement materials and parts, including associated costs and time frames.
- .5 Provide additional information requested by Engineer, including:
 - .1 Demonstration that substitution will perform equally as well or better than specified product(s).
 - .2 Demonstration that other provisions of this Article will be met.
- .6 Clauses such as "or equal", "or approved equal", or other similar clauses, will not be construed as an invitation to submit RFSs or to unilaterally substitute in place of specified requirements.
- .7 Failure to complete Work or portions of Work in adequate time to meet approved construction schedule will not be a valid reason to submit RFSs. Delays remain responsibility of Contractor, with no changes to Contract Price or Contract Time.
- .8 RFSs may be rejected for any reason, including:

- .1 Proposed substitution is not equivalent to the specified product(s), as determined by Engineer.
- .2 RFS does not meet submission requirements or other provisions described in this Article.
- .3 Owner chooses not to entertain RFS.
- .9 In the event a substitution has been incorporated into Work without obtaining written acceptance of the RFS:
 - .1 Contractor shall remove the substitution and replace it with specified requirements, with no changes to Contract Price or Contract Time.
 - .2 Alternatively, should substitution be reviewed by Engineer and later accepted by Owner, Contract Price shall be reduced by the sum of:
 - .1 The amount that the installed price of specified requirements exceeds that of substitution, as determined by Engineer.
 - .2 Engineer fees required to review and evaluate the substitution, regardless if substitution is accepted.
 - .3 Additional engineer fees as required including administering substitution procedures, documentation.
 - .4 The net present value of lifecycle costs resulting from substitution, as determined by Engineer, including energy efficiency, maintenance costs, fees related to application and approval of permits, and modifications to related Work resulting from substitution.
- .10 Substitutions shall not result in any delay in completion of Work, including other activities and projects under separate contracts by Owner.
- .11 Substitutions shall not result in any increase in Contract Price and Contract Time.
- .12 Should changes be required due to substitutions, such changes shall be made by Contractor, with no changes to Contract Price or Contract Time, whether or not such changes are known at the time substitution is accepted. Changes may result in additional costs incurred by Owner.

1.15 DELEGATED PROFESSIONAL DESIGN

- .1 Delegated Professional Design: Where indicated, engage services of a professional engineer to provide design documents. Design documents to include drawings and specifications, and other activities as required for each of the following purposes:
 - .1 Construction.
 - .2 Submission to authorities having jurisdiction, including permit application or amendment, variance application.
 - .3 Record drawings.
 - .4 Other purposes as required.
- .2 Documents prepared under Delegated Professional Design to be sealed, signed, and dated by a professional engineer working under a Certificate of Authorization.
- .3 Professional engineer and services provided by Certificate of Authorization holder to include:
 - .1 Insurance
 - .1 Errors and Omissions (Professional Liability) Insurance: Certificate of Authorization holder to have minimum \$1,000,000 per occurrence and minimum \$2,000,000 aggregate. Submit proof upon request.
 - .2 Additional Insured: Certificates of insurance issued able to meet Owner requirements including additional insured text. Submit proof upon request.
 - .2 Licences: Submit proof upon request, including individual licence number(s) and Certificate of Authorization number.
 - .1 Professional Engineer: Licensed to practice professional engineering in the province of Ontario.
 - .2 Certificate of Authorization Holder: Holder of a Certificate of Authorization issued by Professional Engineers Ontario.

- .3 References: References of professional engineer, including previous recent project work. Submit upon request.
- .4 Drawings
 - .1 Drawings to be completed and provided to Engineer in editable electronic files for shop drawings and project record drawings in AutoCAD format, compliant to CAD standards of Owner or Engineer as determined by Engineer, including:
 - .1 Background template, title block and attributes.
 - .2 Layers naming and use.
 - .2 Drawings to include the following content and features:
 - .1 Differentiation between new and existing.
 - .2 Schedules or details on equipment, materials, and certifications.
 - .3 Material characteristics.
 - .4 Details on interfacing.
 - .5 Dimensionally accurate plan views of the affected areas.
 - .6 Dimensionally accurate layouts and details.
 - .7 Flow schematics.
 - .8 Top view, side view, and 3-dimensional view details where necessary to show specific aspects of design.
 - .3 Drawings to also include the following details:
 - .1 Project name, building name, building address.
 - .2 Owner name.
 - .3 Issued for purpose.
 - .4 Name, contact information, and graphical identification marks of Certificate of Authorization holder under which Delegated Professional Design is being performed.
- .5 Scope
 - .1 Scope of responsibility covered by engineering seal applied to Delegated Professional Design documents to include design being suitable for intended purpose in final application, including applicable requirements being met.
 - .2 Delegated Professional Design documents may be submitted to authorities having jurisdiction. Provide additional information that may be requested by such authorities, including design parameters, calculations, or other details.
 - .3 Prohibited
 - .1 Statements that limit the scope of responsibility covered by the engineering seal applied to Delegated Professional Design documents, except as may be accepted by Engineer.
 - .2 Delegation of professional engineering to any other party.
- .6 General Reviews
 - .1 For content of Delegated Professional Design, provide general reviews during and following construction completed by same professional engineer who sealed Delegated Professional Design documents, whether or not general reviews are specifically required by regulation.
 - .2 Complete relevant portions of required and applicable regulatory permitting documents, including general review commitment forms.

1.16 GENERAL REVIEWS

- .1 Terms
 - .1 “General review” in Contract Documents is same as defined by regulation, including local building code, professional practice guidelines, or the same as other terms such as “conformance review” or “general assessment” for the whole of or any part of Work as determined by Engineer, including general review not specifically required by regulation including local building code.
 - .2 “Engineer” in this article is either Engineer as already defined, or professional engineer under Delegated Professional Design, as required for the whole of or any part of Work.

- .2 Purpose: General reviews are completed by Engineer as required for the purpose of reviewing whether Work is in general conformance with the design concept, and completed to regulatory requirements.
 - .1 No implied approval or acceptance of submittals, substitutions, or changes shall be inferred from general reviews.
 - .2 No implied approval or acceptance of changes in Contract Price and Contract Time shall be inferred from general reviews.
 - .3 General reviews are not to be relied upon for testing, commissioning, and required inspections by authorities having jurisdiction or other quality assurance purposes.
 - .4 General reviews do not relieve Contractor of responsibility for meeting all requirements of Contract Documents.
- .3 Frequency: Frequency of general reviews determined by Engineer during Contract Time or after Contract Time.
 - .1 General reviews will continue to be made until the final general review.
- .4 Reports: Engineer will submit a report for each general review.
 - .1 General review reports may include references to other documents that are considered as part of the general review report.
 - .2 Notify Engineer in writing within 3 working days of receiving general review report should Contractor disagree with items noted in report including references.
- .5 Punch Lists: Prepare and maintain on site a comprehensive list of items to be completed and corrected to make Work ready for acceptance by Owner.
 - .1 Update punch list with items described in general review reports.
 - .2 Immediately correct deficiencies and incomplete items described in general review reports at no change in Contract Price or Contract Time.
- .6 Final General Review
 - .1 Submit written request for final general review indicating completion of Work. Include date and signature.
 - .2 Final general review request will imply, whether stated or not, the following:
 - .1 Statement that all outstanding general review items have been rectified.
 - .2 Declaration that Contractor has prepared and completed all final completion submittals as described below.
 - .3 Upon receipt of request, Engineer will proceed with final general review.
 - .4 In the absence of written request for final general review, final general review will be completed after Substantial Performance has been first requested.

1.17 QUALITY CONTROL

- .1 Quality Assurance: Ensure products, services, workmanship and site conditions comply with requirements by coordinating, supervising, testing and inspecting Work, and by utilizing only suitably qualified personnel.
- .2 Minimum Quality: Where no quality basis is prescribed, quality shall be in accordance with the more stringent of:
 - .1 Best accepted practices of the construction industry for projects of this type, and in this location.
 - .2 Quality of the latest changes and renovations to the existing building installation, as it exists now.
 - .3 Quality of the existing base building installation, as it existed when newly installed.
- .3 Quality of Installation: Produce Work plumb, level, square and true, or true to indicated angle, and with proper alignment and relationship between the various elements. Ensure Work is properly related to form close joints and appropriately aligned junctions, edges and surfaces and is free of warp, twist, wind, wave or other irregularities.
- .4 Manufacturer's Instructions and Recommendations: Comply with manufacturer's instructions in preparing, fabricating, erecting, installing, applying, connecting and finishing Work, unless more stringent requirements are required, indicated or specified.

- .5 Protection: Take measures necessary to preserve and protect existing and completed Work free from damage, deterioration, soiling and staining, until Acceptance by Owner.
- .6 Defects and Blemishes: Correct defects, blemishes and other aesthetic issues identified by Engineer.
- .7 Deviations: Document and explain deviations from requirements, including applicable standards, referenced documents, building code research report requirements, and manufacturer's product installation instructions and recommendations. Include written acknowledgment by manufacturer that such deviations are acceptable and appropriate for Work. Ensure Work does not infringe on applicable patents or intellectual property rights.
- .8 Photo Documentation
 - .1 Photo document construction progress with time stamped digital photographs.
- .9 Logs: Maintain daily sign in and sign out logs for all personnel on site. Owner may dictate location of logs.
- .10 Verification of Quality: Work shall be subject to verification of quality by Owner or Engineer in accordance with provisions of Contract Documents.
- .11 Inspections and Tests
 - .1 Inform Owner and Engineer of required inspections, tests, and reviews, including those required by:
 - .1 Conditions of warranty.
 - .2 Product, material or equipment manufacturers.
 - .3 Certification of Work.
 - .4 Commissioning.
 - .5 Contract Documents.
 - .6 Authorities having jurisdiction.
 - .7 Regulation.
 - .2 Contact manufacturers, suppliers, authorities having jurisdiction, and others as required sufficiently in advance to confirm which, if any, inspections, tests, and reviews are required, including when required as a condition of permits, certificates, and licences not obtained by Contractor.
 - .3 Make arrangements for required inspections, tests and reviews. Coordinate dates and times that are acceptable to Owner and Engineer.
 - .4 Participate in and be present during inspections, tests and reviews, as well as additional follow-up inspections, tests and reviews.
 - .1 Arrange and pay for the presense and participation of manufacturers, suppliers, service representatives, subcontractors, authorities having jurisdiction, and others that may be required to be present during such activities.
- .12 Monitoring: Owner may monitor construction site including video surveillance to document construction progress and to provide evidence for valuing Change Directives.

1.18 USE OF SITE AND PREMISES

- .1 Schedule Restrictions
 - .1 Schedule daily and weekly construction activities as required by Owner.
 - .2 Schedule Work around:
 - .1 Work being performed by others under separate contracts with Owner.
 - .2 Normal use of the facility, including in areas affected by Work.
 - .3 Schedule Work outside of occupied hours for:
 - .1 Work requiring disruption of services to occupiable areas.
 - .2 Work that may disrupt or disturb occupants.
- .2 Request clarification of all matters regarding the use of site and premises that may impact construction activities.
- .3 Meet Owner requirements during construction including:
 - .1 Allowable construction hours.
 - .2 Notices and scheduling of Work.
 - .3 Notices and scheduling of disruption of services.

- .4 Facilities and utilities use.
- .5 Parking.
- .6 Security requirements.
- .7 Identification requirements.
- .8 Access requirements including availability and requirements of use for elevators, loading areas and pathways.
- .9 Disruption mitigation requirements including noise, vibration, dust, combustion gases, and smoke.
- .10 Submission of written plans for various aspects of Work, including phase-in planning, disruption mitigation, emergency procedures, Methods of Procedures (MOP).
- .11 Hazardous materials.
- .12 Storage requirements.
- .13 Disposal requirements including for garbage and debris.
- .14 Cleanliness and organization of work areas including for tools, materials, equipment.
- .15 Cleanliness and visual appearance of areas affected by Work.
- .16 Protection of surfaces and other items affected by Work.
- .4 Emergency Egress: Maintain means of egress during construction including pathways, exit ways, exit doors, drives, gates, as required by Owner and authorities having jurisdiction.
- .5 Disruption
 - .1 Do not disrupt facility except as specifically permitted in Contract Documents.
 - .2 Disruption of facility includes interference with:
 - .1 Maintenance activities, site staff, Engineer or Owner's access to facility.
 - .2 Normal use of facility, including activities that may be temporarily suspended as a result of Work, either within or outside of areas affected by Work.
 - .3 Activities temporarily suspended as a result of Work may resume at various milestone dates, including full resumption of normal facility use in all areas as of the date substantial performance is required to be achieved, regardless of whether or not substantial performance is actually achieved by this date.

1.19 TEMPORARY FACILITIES AND CONTROLS

- .1 Provide temporary facilities and controls as required.
- .2 Temporary Utilities
 - .1 Provide temporary utilities as required, including electrical, lighting, water, heating, cooling, and ventilation as required.
 - .2 Co-ordinate utility disruption and provision of temporary utilities as required by Owner to prevent interruption of building occupant activities.
 - .3 Coordinate with Owner for points of connection, protection and payment of service charges.
 - .4 Exercise measures to conserve energy.
 - .5 Provide temporary emergency backup power in the event of interruption of existing power including backup standby power.
- .3 Temporary Services: Provide temporary services as required, including lighting, pumping, heating, ventilation, cooling, and de-humidification. Temporary services may be required of Work space or other spaces. Purposes of temporary services include:
 - .1 Maintain occupant comfort.
 - .2 Maintain building environment.
 - .3 Maintain equipment and system redundancy requirements.
 - .4 Maintain safety systems.
 - .5 Maintenance protection.
 - .6 Prevent interference or disruption of occupant operations.
 - .7 Prevent damage, including to areas, systems, services, equipment, components, finishes.
 - .8 Provide adequate temperature and humidity levels for storage, curing or drying.
 - .9 Prevent migration and accumulation of dust, debris, fumes, smoke, gases, or odours.
 - .10 Prevent flooding and standing water.

- .11 Prevent spills.
- .4 Work Protection: Provide temporary protection for installed products and services. Control traffic in immediate area to minimize damage.
- .5 Protective Coverings: Provide protective systems and barriers at services and systems, including at air inlets and grilles, to prevent maintenance and operational impacts outside of working area. Includes noise, sound, vibration, dust, debris, fumes, smoke, gases, odours.
- .6 Surfaces Protection
 - .1 Protect existing surfaces from soiling and damage, including floors, with protective covering as required.
 - .1 Minimum for Floors
 - .1 2 layers of 0.08-mm (3-mil) polyethylene sheets, extending sheets 460-mm (18-in) up the side walls.
 - .2 Cover polyethylene sheets with minimum 25-mm (1-in) fire-retardant plywood.
 - .2 Provide mats to clean dust and debris from traffic entering and existing the Work space.
- .7 Temporary Barriers: Provide temporary fencing, barriers and guardrails as necessary to provide for public safety, to prevent unauthorized entry to construction areas, and to protect existing facilities and adjacent properties from damage from construction operations.
- .8 Temporary Closures: Provide temporary closures for protection of construction, in progress and completed, from exposure, foul weather, other construction operations and similar activities. Provide temporary weather-tight enclosure for building exterior.
- .9 Temporary Communications: Provide temporary communications as required for proper performance of the Work.
- .10 Other Temporary Provisions
 - .1 Maintain safety systems and occupant protection.
 - .2 Provide temporary fencing, trailers, sanitary facilities, and other structures as required. Obtain approval for type, aesthetics, and location.
- .11 Supervision: Provide supervision of temporary facilities and controls, including utilities and HVAC, where disruption or failure of such services may impact occupants, cause interruption of critical services, cause safety concerns, increase risk to life and property, cause other damages.
- .12 Removal of Temporary Facilities and Controls
 - .1 Remove temporary facilities and controls, including utilities, equipment, materials, prior to Substantial Performance Review.
 - .2 Remove underground installations to a minimum depth of 610-mm (2-ft). Grade site as required.
 - .3 Clean and repair damage caused by installation or use of temporary facilities and controls.
 - .4 Restore existing and permanent facilities used during construction to original condition. Restore permanent facilities used during construction to condition equal to or better than at commencement of construction.

1.20 UNKNOWN SITE CONDITIONS

- .1 If all of the following conditions exist, Contractor shall stop Work and give written notice of the conditions before they are disturbed, and in no event later than 5 working days after first observance of the conditions.
 - .1 Nature of condition is hidden or concealed from visual inspection or other inspection responsibilities identified in the Bid Documents.
 - .2 Condition is materially different from those indicated in Contract Documents.
 - .3 Condition is materially different from those indicated in Additional Technical Information.
 - .4 Condition is materially different from those normally encountered.
- .2 Contract dates including Contract Time may be considered for change only when all of the following conditions exist:

- .1 Work is complete in other areas without unknown conditons.
- .2 Contractor is not able to complete Work in areas with unknown conditons encountered or suspected.
- .3 Owner has not completed addressing any issues surrounding such conditions.

1.21 CLARIFICATION PROCEDURES

- .1 Request for Clarification (RFC): A document submitted by Contractor requesting clarification of a portion of Contract Documents, hereinafter referred to as an RFC.
 - .1 Submit a written RFC when any of the following occur:
 - .1 Requirement Unclear: Exact material, process, or system to be installed is unclear.
 - .2 Interference: Elements of construction are required to occupy the same space.
 - .3 Requirements Conflict: Work is described differently in more than 1 place.
 - .2 RFCs shall not be used for the following purposes:
 - .1 To request review of submittals.
 - .2 To request approval or acceptance of substitutions.
 - .3 To request changes that only involve change in Contract Price and Contract Time.
 - .4 To request methods of performing Work different than as indicated.
 - .3 Requested Information: RFCs that request interpretation of requirements clearly indicated in Contract Documents will be returned without interpretation.
 - .1 In cases in which RFCs are issued to request clarification of issues related to means, methods, sequences, techniques, and procedures of construction, Contractor to furnish information required for Engineer to analyze and/or understand the circumstances causing the RFC and prepare a clarification or direction as to how Contractor shall proceed. Examples include services routing including piping and ductwork, specific locations of Work shown diagrammatically, clearances indicated or required, apparent interferences.
 - .2 If information included with this type of RFC by Contractor is insufficient, the RFC will not be answered.
 - .2 Disputed Requirements: In the event that Contractor believes that a clarification by Engineer results in changes to Contract Price or Contract Time, Contractor is to not proceed with Work indicated by the RFC until authorized to proceed by Owner and Engineer and claims, if any, are resolved in accordance with Contract provisions.

1.22 CONTRACT MODIFICATION PROCEDURES

- .1 Instruction Supplement: Consultant will issue an Instruction Supplement (Supplemental Instruction) authorizing changes in Work not involving adjustment to Contract Price or Contract Time.
- .2 Change Proposal: If conditions require modifications to Contract Documents and upon written request from Engineer, Contractor may document potential impacts to Contract Documents through submitting a Change Proposal. Adhere to instructions from Engineer which may include the following:
 - .1 Description of proposed change.
 - .2 Reason for change.
 - .3 Impacts to Contract Price, with additional details for explanation, including costs and hours from own forces, subcontractors, materials.
 - .4 Impacts to Contract Time, other Contract dates, or construction schedule, with additional details for explanation.
- .3 Change Order: On Owner's approval of a Change Proposal, Engineer will issue a Change Order for signature by Owner and Contractor.

1.23 COMMISSIONING REQUIREMENTS

- .1 Summary
 - .1 Contractor is responsible for implementing and completing commissioning activities to this Section.

- .2 Commissioning is additional to activities indicated including start-up, quality control, quality assurance, testing and balancing.
- .3 Commissioning is a prerequisite requirement for Substantial Performance application.
- .2 Definitions
 - .1 “Commissioning”: A planned program of tests, procedures and checks carried out systematically on systems and integrated systems of Work.
 - .2 “Commissioning Plan”: A plan that details the intent, responsibilities, extent and submittals of commissioning that will be used to meet commissioning objectives.
 - .3 “Demonstrations”: A test or simulation whereby evidence of properly functioning equipment or systems is provided by means of independent third party witnessing.
 - .4 “System State”: A recorded snapshot of the system operation, including temperature, humidity, pressure, flow, amperes, actuator position, efficiency.
- .3 Objectives
 - .1 Commission systems, services, equipment and components directly or indirectly impacted by Work unless otherwise indicated.
 - .2 Verify and provide documented evidence that installed systems, services, equipment and components operate to Contract Documents and design intent.
- .4 Quantities
 - .1 Provide 3 half days commissioning sessions on site after construction has been completed.
- .5 Commissioning Procedures
 - .1 Complete commissioning activities to Commissioning Plan and Specifications.
 - .2 Complete commissioning activities to approved schedule.
 - .3 Submit commissioning submittals.
 - .4 Arrange and facilitate demonstrations.
- .6 Referenced Documents
 - .1 ASHRAE-202: ANSI/ASHRAE/IES-202-2013 Commissioning Process for Buildings and Systems.
 - .2 ASHRAE-G-0: ASHRAE-G-0-2013 Guideline on The Commissioning Process.
 - .3 ASHRAE-G-0.2: ASHRAE-G-0.2-2015 Guideline on The Commissioning Process for Existing Systems and Assemblies.
 - .4 ASHRAE-G-1.1: ASHRAE-G-1.1-2007 Guideline on HVAC&R Technical Requirements for the Commissioning Process.
 - .5 ASHRAE-G-11: ASHRAE-G-11-2009 Guideline on Field Testing of HVAC Controls Components.
 - .6 ACG-CG: ACG Commissioning Guideline 2005.
- .7 Commissioning Submittals
 - .1 Documentation
 - .1 Warranties.
 - .2 Certifications.
 - .3 Test results.
 - .4 Quality control and quality assurance submittals.
 - .5 Commissioning activities.
 - .6 Closeout submittals.
 - .2 Documentation of System State at full and part load conditions for the following states and modes of operation:
 - .1 Start-up conditions.
 - .2 Normal operating conditions.
 - .3 Simulated maximum capacity.
 - .4 Simulated minimum capacity.
 - .5 All other modes of operation.
 - .6 Interlocks and failure modes.

- .3 Letter certifying that Work has been installed and commissioned according to Contract Documents.
- .4 Submittals shall include the time, date, and the person(s) who completed commissioning activities.
- .8 Demonstrations
 - .1 Demonstrations shall be witnessed by Engineer, Owner, or approved third party Commissioning Authority.
 - .2 Demonstrate the following quantity of components, equipment and systems unless otherwise indicated.
 - .1 Quantity 10 or 10-% of the total quantity, whichever is greater, of each distinct type of component, equipment and system as determined by Engineer.
 - .3 Demonstrate performance including:
 - .1 System is working in accordance with design intent.
 - .2 Capacity, staging control, and efficiency of equipment at full and part load scenarios.
 - .3 Modes of operation for all equipment and systems.
 - .4 Interlocks including fire alarm, equipment fail-safe, over-current, over-vibration, flow, low level, over temperature, over pressure, gas detection, and other life safety interlocks or safeties required for safe operation.
 - .5 Equipment and component failure and fail-over modes and test consequences and responses.
 - .6 Other demonstrations upon request.

1.24 FINAL COMPLETION SUBMITTALS

- .1 Project Drawings: Provide drawing types and formats as follows.
 - .1 Drawing Type - Contractor As-Built Marked-Up Drawings
 - .1 Mark up prints to show the actual installation where installation varies from that shown in previous and most recent complete drawing sets.
 - .2 Provide complete details on concealed elements that cannot be readily identified and recorded later, including layouts, schematics, products, components, installation methods.
 - .3 Markups to be made with non-eraseable red colour lines. Use other colors to distinguish between changes for different categories of Work at the same location.
 - .4 Prominently cross out the following components from each drawing sheet:
 - .1 Engineer's logo and address.
 - .2 Engineering seal(s).
 - .5 Identify and date each drawing sheet including the designation "AS-BUILT DRAWING" in a prominent location, whether or not there are markups on each sheet.
 - .6 Apply Contractor stamp in red non-eraseable ink to each drawing sheet.
 - .2 Drawing Format
 - .1 Printed: ANSI D size paper unless otherwise indicated. Colour.
 - .1 Organize into manageable sets. Bind each set with durable paper cover sheets. Include identification on cover sheets.
 - .2 Electronic: Adobe PDF format of drawing contents.
 - .3 Drawing Type - Project Design Drawings
 - .1 Drawings provided by Engineer in electronic format to reflect consolidation of agreed changes to contract documents for which Engineer is assuming design responsibility.
 - .2 Format: Printed
 - .4 Drawing Type - Project As-Built Drawings
 - .1 Drawings provided by Engineer in electronic format based on Contractor As-Built Marked-up Drawings.
 - .2 Format: Printed

- .2 Project Binders: Provide binders in the formats, types, and with contents as follows.
 - .1 Binder Formats
 - .1 Paper Format
 - .1 Bound and indexed binder volume sets.
 - .2 Each binder type and copy of each binder within a single binder, unless otherwise accepted by Engineer or Owner.
 - .3 Thickness as necessary to accommodate contents and ensure ease of use.
 - .4 Matching heavy duty, 3-ring loose-leaf binders, having clear vinyl pouch on front and spine for title page and spine index insertion.
 - .5 Front cover and spine indexed, formatted and containing content including binder volume number, client project number, project name, date of substantial completion, site name, site address, and client site ID number.
 - .6 Plastic sheet lifter to facilitate page turning.
 - .7 Table of contents located on front page, laminated with reinforced holes, and including contents of multiple binder volume set.
 - .8 Section dividers.
 - .9 Paper format of contents. Colour.
 - .10 Electronic version of all contents, contained in a sleeved inside each binder type, in both DVD(s) and USB flash drive(s).
 - .2 Electronic Format
 - .1 Format: Adobe PDF.
 - .2 Organization: Individual folders and files, with appropriate and representative names for recognition and ordering.
 - .2 Binder Type - Project Record Manual
 - .1 Contract: Contract documents, including signed contracts, bonding and insurance documentation.
 - .2 Drawings: All issued drawings sets including those issued for tender, permits, changes, Contractor As-Built Marked-Up, Project Design, Project As-Built.
 - .1 Paper Format: Size ANSI B or ANSI C as acceptable to Engineer.
 - .3 Specifications
 - .4 Meetings: Meeting agendas, minutes, memos, and communications.
 - .5 Submittals: Contract submittal information including submittals and reviews.
 - .6 Instructions and Clarifications: Contract instruction supplements including clarification information.
 - .7 Changes: Contract change documentation including notices, proposals, reviews, orders, directives.
 - .8 Notices: Contract notices in writing, written statements.
 - .9 Site Reviews: Site reviews, reports, deficiency lists, observation lists.
 - .10 Payments: Contract payment documentation including certification, reviews.
 - .11 Permits: Application documents and approvals for permits, certificates, licenses, testing and inspections required including regulatory.
 - .12 Certificates: Other documents including certificates demonstrating compliance with requirements including regulatory.
 - .13 Guaranties and Warranties: Contract and overall project.
 - .14 Lien Documentation
 - .3 Binder Type - Operating and Maintenance Manual
 - .1 Products
 - .1 Bill of Materials: Include tag, description, quantities, makes, and model numbers or part to be ordered. Model numbers to be complete, including selected features and options, special instructions or custom aspects.
 - .2 Submittals: Manufacturer's submittals or product data. Indicate selected features and options on each submittal page or product sheet by using annotation boxes or highlights.

- .3 Product Data: Manufacturer's information on products, shop drawings, specifications, installation manuals, operation manuals, warranties.
- .4 Maintenance Data: Manufacturer's information, list of spare parts, maintenance procedures, maintenance and service schedules for preventive and routine maintenance
- .5 Operating Data: Emergency instructions and procedures, system and equipment descriptions, operating procedures, health and safety information, troubleshooting procedures, and sequence of operations.
- .6 Maintenance contracts.
- .2 Systems
 - .1 Submittals: System related submittals and documents, including shop drawings, schematics, layouts, diagrams.
 - .2 Tests: Balancing, measurements and testing data and reports.
 - .3 Commissioning: Data and reports.
 - .4 Other submittals as required.
 - .5 Maintenance contracts.
- .4 Binder Type - Training Manual
 - .1 Software user manuals.
 - .2 Software training manuals.
 - .3 Training documentation, presentation slides, and other training related documentation.
 - .4 Sleeve containing DVD(s) of training videos, tutorial software, and other media related to training.
- .3 Provide other closeout items including:
 - .1 Spare parts and materials.
 - .2 Software and license codes, including specific assignment of ownership to Owner requirements.
 - .3 Tools.
 - .4 Keys.
- .4 Acceptance Procedures and Final Copies
 - .1 Prior to Substantial Performance application, complete and submit each binder type to Engineer, Owner, and Commissioning Authority for review and acceptance. Submit electronic copies, as well as printed copies if required by Owner.
 - .2 Acceptance Criteria
 - .1 To the more stringent of the following, including quality, content, and format:
 - .1 ASHRAE-G-4: ASHRAE-G-4-2008 (RA 2013) Preparation of Operating and Maintenance Documentation for Building Systems.
 - .2 Additional requirements indicated in commissioning requirements.
 - .3 Create, add or modify and resubmit as required, including quality, content, and format.
 - .4 Upon written acceptance, provide 3 final copies of each document, binder or drawings set, in addition to electronic formats.

1.25 TRAINING REQUIREMENTS

- .1 Provide sufficient training to deliver a thorough understanding of operation and maintenance of all systems, equipment, and components and their interrelationship with other systems.
- .2 Provide training on the following systems and equipment:
 - .1 Systems, equipment, components and services.
 - .2 Control systems.
 - .3 Equipment and components requiring control.
 - .4 Systems, equipment and components requiring manufacturer's start-up activities.
 - .5 Fluid treatment and filling.
- .3 General Training
 - .1 Provide the following training sessions on indicated training topics.

- .2 General Structure
 - .1 Classroom based training at Owner's preferred location on site, unless otherwise indicated.
 - .2 Walk through of facility areas and rooms to identify locations of equipment and components, familiarization of systems and equipment.
 - .3 Training documentation, including presentation slides, tutorial software, and other media related to training.
 - .4 Hands-on demonstrations with attendee involvement.
 - .5 Questions and answers period.
 - .6 Additional requirements as indicated in commissioning requirements.
- .3 Quantities
 - .1 Provide training sessions as indicated below each for up to 8 attendees excluding instructors.
 - .2 Provide 2 half day training session(s) after major construction has been completed and before Substantial Performance.
 - .3 Provide 1 additional half day training session(s) 6 months following Substantial Performance.
 - .4 Provide 1 additional half day training session(s) after above but before end of warranty period and scheduled to capture seasonal operational variance due to weather and/or operations.
- .4 Topics: Include the following training topics on indicated systems and equipment:
 - .1 Overview and Description
 - .1 Design intent.
 - .2 System capabilities, modes of operation, and limitations.
 - .3 System sequences of operation for all modes of operation.
 - .4 Acceptable tolerances for system adjustments in all operating modes.
 - .2 Operations and Documentation
 - .1 Overview and use of documentation including product literature and operating manuals.
 - .2 Overview of independent controllers including programming, sequences, settings, troubleshooting, alarms, manual overrides, interfaces.
 - .3 Overview of digital controllers including programming, sequences, settings, troubleshooting, alarms, manual overrides, interfaces.
 - .4 Overview of controllers interfacing with other controllers, including digital, independent, equipment.
 - .5 Procedures for abnormal and emergency operating situations, including during power outage and fire.
 - .6 Procedures for conservation operating modes and strategies including utilities, energy, demand.
 - .7 Health and safety issues, concerns, personal protective gear, and special safety features.
 - .8 Recommended site informative documentation, including labels, posted instructions, posted documents, safety signage.
 - .3 Maintenance and Materials
 - .1 Overview and use of maintenance manuals.
 - .2 Troubleshooting procedures.
 - .3 Service, maintenance, and preventive maintenance requirements including scheduling, frequency and administrative procedures.
 - .4 Review of spare parts inventory, special tool use, and service contacts.
 - .5 Health and safety issues, concerns, personal protective gear, and special safety features.
- .4 Training Providers
 - .1 Personnel Qualifications

- .1 Experienced and skilled in training to target audience including:
 - .1 Owner representatives.
 - .2 Facility managers.
 - .3 Project managers.
 - .4 Operations staff.
 - .5 Tenant/occupant representatives.
 - .6 Service and maintenance staff.
- .2 Experienced and skilled in training with a wide variety of topics including:
 - .1 Installation.
 - .2 Start-up.
 - .3 Troubleshooting.
 - .4 Service and maintenance.
 - .5 Emergency operations.
- .3 Full time employees on the staff of the listed training provider types.
- .2 Training Provider Types
 - .1 Manufacturer: The product manufacturer.
 - .2 Manufacturer's Representative: The product manufacturer's local authorized product representative for product sales and service.
 - .3 Manufacturer's Start-up: The product manufacturer's local authorized start-up and troubleshooting for product.
 - .4 Installer: The installer of products and systems on this project.
 - .5 Service Company: The company providing service for the installed products and systems.
- .3 Specific Training Providers: Use the following approved service providers for applicable training activities:
 - .1 Ventilation Equipment: Manufacturer and manufacturer's start-up.
 - .2 Building Automation Systems: Manufacturer and manufacturer's start-up and service company.
 - .3 Fire Protection System: Owner's fire protection service company(s).
 - .4 Fluid Treatment: Owner's fluid treatment service company(s).
 - .5 Other: Manufacturer's representatives and manufacturer's start-up for systems, equipment and components requiring manufacturer's start-up services.
- .4 Personnel Coordination
 - .1 Controls Interfacing: All training providers and personnel to be present when training is occurring for controllers that are interfacing with other controllers, including digital, independent, equipment.
- .5 Alternate providers will not be accepted.
- .5 Training Plan
 - .1 Prepare and submit training plan to Owner including the following:
 - .1 Schedule, location, duration, instructor names and qualifications, and detailed itinerary of training topics to be covered.
 - .2 Copies of training documentation to be provided.
 - .2 No later than 4 weeks prior to Substantial Performance, complete and submit details of training plan for review and acceptance.
 - .3 Create, add or modify training plan and resubmit as required.
 - .4 Upon acceptance, coordinate, arrange, and deliver training in accordance with accepted plan.
- .6 Additional Owner Requirements
 - .1 After training sessions, meet with Owner representatives including site Occupational Health and Safety Committee to review additional requirements that may be required for the site including signage, additional training.

1.26 ADDITIONAL RESPONSIBILITIES

- .1 Adherence to Procedures

- .1 Failure to adhere to procedures, including submittals and changes, in no way relieves Contractor of their responsibility for Work.
- .2 Site Reviews Before Proceeding
 - .1 Contractor to complete site visits to inspect the general and local site conditions that could affect Work.
- .3 Non-conforming Work
 - .1 When Contractor seeks additional opinion regarding conformance of Work, Contractor to retain and pay for a representative(s) from applicable entity to review or inspect Work for such entity to provide opinion. Opinion from such entity will be subject to review by Engineer, as well as resubmission by entity. Entities include:
 - .1 Products: Manufacturer's representative.
 - .2 Regulatory: Authority having jurisdiction.
 - .3 Service: Owner's service contractor.
 - .2 Correct non-conforming Work, with no changes to Contract Price or Contract Time.
- .4 Additional Fees from Engineer
 - .1 Certain actions or omissions by Contractor may result in Engineer charging additional fees to Owner. Should this occur, Owner may choose to modify Contract Price through Contract change procedures by deducting some or all of the value of these additional fees charged by Engineer. Actions or omissions of Contractor that may result in Engineer charging additional fees to Owner may include:
 - .1 Failing to meet construction schedule including milestone dates. Activities of Engineer that may contribute to additional fees charged to Owner may include:
 - .1 Additional project or commissioning meetings.
 - .2 Additional site visits.
 - .3 Additional deficiency lists and deficiency reviews.
 - .4 Additional General Reviews.
 - .5 Additional payment certifications.
 - .6 Administration of additional related changes to Contract.
 - .2 Submission of Request for Substitution, whether or not such request is in the prescribed form. Activities of Engineer that may contribute to additional fees charged to Owner may include:
 - .1 Reviewing and responding to Request for Substitution.
 - .2 Redesigning aspects of Work as a result of substitution.
 - .3 Actions or omissions resulting in Engineer repeating activities that may include:
 - .1 Commissioning activities.
 - .2 Project or commissioning meetings.
 - .3 Site visits.
 - .4 Deficiency lists and deficiency reviews.
 - .5 General reviews.
 - .6 Payment certifications.
 - .2 Additional Engineer fees include time, travel expenses, other related expenses.
- .5 Contract Dates
 - .1 Owner may incur significant costs as a result of Contractor failing to meet contractual obligations, including:
 - .1 Milestone dates.
 - .2 Disruption of services beyond permitted durations.

END OF SECTION 01 00 00

SECTION 05 10 00 STRUCTURAL METAL

PART 1 GENERAL

1.1 SECTION INCLUDES

- .1 Structural metal and related hardware for field fabricated and mounted systems and assemblies, including beams and frames, supports around openings, platforms, railings, lifting lugs and beams, and other supports and hangers for equipment, systems and components.
- .2 Section does not include pre-engineered manufactured systems and assemblies.

1.2 REFERENCED DOCUMENTS

- .1 ASTM-A123: ASTM-A123/A123M-15 Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
- .2 ASTM-A153: ASTM-A153/A153M-09 Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
- .3 ASTM-F3125: ASTM-F3125/F3125M-15 Standard Specification for High Strength Structural Bolts, Steel and Alloy Steel, Heat Treated, 120 ksi (830 MPa) and 150 ksi (1040 MPa) Minimum Tensile Strength, Inch and Metric Dimensions.
- .4 CGSB-85.10: CAN/CGSB-85.10-99 Protective Coatings for Metals.
- .5 CGSB-85.100: CAN/CGSB-85.100-93 Painting.
- .6 CSA-G40.20/21: CSA-G40.20-13/G40.21-13 General Requirements for Rolled or Welded Structural Quality Steel/Structural Quality Steel.
- .7 CSA-S16: CAN/CSA-S16-14 Design of Steel Structures.
- .8 CSA-W47.1: CSA-W47.1-09 (R2014) Certification of Companies for Fusion Welding of Steel.
- .9 CSA-W47.2: CSA-W47.2-11 (R2015) Certification of Companies for Fusion Welding of Aluminum.
- .10 CSA-W48: CSA-W48-14 Filler Metals and Allied Materials for Metal Arc Welding.
- .11 CSA-W59: CSA-W59-13 Welded Steel Construction (Metal Arc Welding).

1.3 SUBMITTALS FOR ACTION

- .1 Shop Drawings
 - .1 Layout and Interference Plans: Scaled drawings indicating clearances, interferences, and relocation of interfering services, components, objects, and structures.
 - .2 Mounting: Drawings for equipment mounting including:
 - .1 Dimensions and construction for beams, frames, supports, curbs.
 - .2 Maximum load at point loads.
 - .3 Details of supplementary structural steel framing members.
 - .4 Details of joining including welding and fasteners.
 - .3 Support: Structural steel and related hardware for systems including platforms, supports around openings, lifting lugs and beams, and other supports and hangers for equipment, systems and components.

1.4 SUBMITTALS FOR INFORMATION

- .1 Delegated Professional Design Submittals
 - .1 Design and design documents completed by a professional engineer for the following:
 - .1 Structure and modifications as installed does not exceed structural limits and requirements, including seismic provisions of local building code. Engineered drawings and record drawings of existing installation may not be available or may not exist including design drawings, shop drawings.
 - .2 Mounting of equipment, services and components as installed does not exceed structural limits of structure, including seismic provisions of local building code. Engineered drawings and record drawings of existing installation may not be available or may not exist including design drawings, shop drawings.

- .3 Mounting systems and components are suitable for application and requirements, including seismic provisions of local building code.
- .4 Mounting components and restraints are suitable for application and requirements, including seismic provisions of local building code.
- .2 Qualification Statements
 - .1 Welding: Proof of certifications for company and personnel.
 - .2 Professional Engineering: Proof of licences for company and personnel.

1.5 SUBMITTALS FOR CLOSEOUT

- .1 Certificates
 - .1 Letter certifying the following meets requirements:
 - .1 Welded connections.
 - .2 Torque applied to bolt tightening.
 - .3 Grouting of drilled inserts.

1.6 QUALITY ASSURANCE

- .1 Qualifications
 - .1 Welding: Company certified by CWB to CSA-W47.1 and CSA-W47.2.
 - .2 Professional Engineering
 - .1 Company and personnel licensed to practice Professional Engineering by PEO.
 - .2 Subject to approval.

PART 2 PRODUCTS

2.1 COMMON PRODUCT REQUIREMENTS

- .1 Materials
 - .1 To CSA-G40.20/21.
 - .2 As required.

2.2 BEAMS

- .1 Provide as required.

2.3 SUPPORT CHANNELS

- .1 Provide as required.

2.4 LINTELS

- .1 Provide as required.

2.5 BOLTS AND NUTS

- .1 Provide as required.
- .2 Materials: Stainless steel.
- .3 Bolts
 - .1 To ASTM-F3125.
 - .2 To CSA-S16.
 - .3 Identifiable with head markings.

2.6 ANCHORS

- .1 Provide as required.
- .2 Manufacturers: Hilti Corp., HY 150
- .3 Type: For use with epoxy grout.

2.7 GROUT

- .1 Provide as required.
- .2 Manufacturers: Sika Canada Inc., Sikagrout 22
- .3 Materials: Epoxy

2.8 PAINT

- .1 Provide as required.
- .2 Type
 - .1 Zinc Rich Paint
 - .1 To CGSB-85.10 and CGSB-85.100.

- .2 Manufacturers: Fosroc International Limited, Galvafroid
- .2 As required where not indicated.

PART 3 EXECUTION

3.1 PREPARATION

- .1 Protection: As required.
- .2 Bracing: Provide sufficient bracing during demolition, removal, and construction.

3.2 NOTIFICATION

- .1 Notify Engineer of schedule and duration of the following work by minimum 2-days in advance before starting Work:
 - .1 Welded connections.
 - .2 Torque applied to bolt tightening.
 - .3 Grouting of drilled inserts.

3.3 COMMON EXECUTION REQUIREMENTS

- .1 Welding
 - .1 To CSA-W59.
 - .2 Filler metals and allied materials to CSA-W48.
 - .3 Prepare galvanized components before welding by scraping off galvanizing prior to welding.
- .2 Coating: Hot-dip galvanize iron and steel components to ASTM-A123 and ASTM-A153.
- .3 Roof Mounted Equipment: Structurally tie supports into building structure.

3.4 BEAMS

- .1 Install as required.
 - .1 Unacceptable: Field drilling of bolt holes.

3.5 DRILLED INSERTS

- .1 Provide as required.
- .2 Blow out holes to remove dust and debris from drill hole prior to grouting.
- .3 Grout to fill in voids as required.
- .4 Tighten structural bolts with torque wrench.

3.6 BOLTS AND NUTS

- .1 Install as required.

3.7 ANCHORS

- .1 Install as required.

3.8 GROUT

- .1 Install as required.

3.9 FINISHING

- .1 Paint components.
 - .1 Prepare and finish paint components before installation.
 - .2 Prepare surfaces.
 - .3 Prime paint field welds with zinc rich paint.
 - .4 Prime paint structural members, excluding stainless steel materials and galvanized components.
 - .5 Touch-up damaged or marked areas with zinc rich paint before finish painting.
 - .6 Finish paint structural members.

END OF SECTION 05 10 00

SECTION 07 52 00 ROOFING

PART 1 GENERAL

1.1 SECTION INCLUDES

- .1 Roofing and waterproofing through and at roofing, including penetrations, structural supports.

1.2 SUBMITTALS FOR ACTION

- .1 Product Data
 - .1 Manufacturers' product literature, specifications, and datasheets. Include product characteristics, performance criteria, options, and limitations.
- .2 Shop Drawings
 - .1 Layout and Interference Plans: Scaled drawings indicating clearances, interferences, and relocation of interfering services, components, objects, and structures.

1.3 SUBMITTALS FOR INFORMATION

- .1 Delegated Professional Design Submittals
 - .1 Design and design documents completed by a professional engineer for the following:
 - .1 Structure and modifications as installed does not exceed structural limits and requirements, including seismic provisions of local building code. Engineered drawings and record drawings of existing installation may not be available or may not exist including design drawings, shop drawings.
 - .2 Design of roofing and waterproofing modifications including roofing, decking, insulation, flashing, sealing.
 - .2 Qualification Statements
 - .1 Professional Engineering: Proof of licences for company and personnel.

1.4 QUALITY ASSURANCE

- .1 Qualifications
 - .1 Roofing: Company member of CRCA and OIRCA.
 - .2 Professional Engineering
 - .1 Company and personnel licensed to practice Professional Engineering by PEO.
 - .2 Subject to approval.

PART 2 PRODUCTS

2.1 COMMON PRODUCT REQUIREMENTS

- .1 Materials
 - .1 As required.
 - .2 Match existing.

2.2 VAPOUR RETARDER

- .1 Provide as required.

2.3 INSULATION

- .1 Provide as required.

2.4 INSULATION ADHESIVE

- .1 Provide as required.

2.5 MEMBRANE FLASHINGS

- .1 Provide as required.

2.6 PITCH POCKETS

- .1 Provide as required.

2.7 PITCH POCKET SEALANTS

- .1 Provide as required.

2.8 CONES

- .1 Provide as required.

2.9 SLEEVES

.1 Provide as required.

2.10 SEALANTS AROUND SERVICES

.1 Provide as required.

PART 3 EXECUTION

3.1 COMMON EXECUTION REQUIREMENTS

.1 Install as required.

END OF SECTION 07 52 00

SECTION 23 00 00 MECHANICAL EQUIPMENT

PART 1 GENERAL

1.1 SECTION INCLUDES

- .1 Heating, Cooling, Pumps, Fans.

1.2 REFERENCED DOCUMENTS

- .1 AHRI-550-590: ANSI/AHRI-550/590/551/591-2015 Performance Rating of Water-Chilling and Heat Pump Water-Heating Packages Using the Vapor Compression Cycle.
- .2 ASHRAE-15: ANSI/ASHRAE-15-2013 Safety Standard for Mechanical Refrigeration.
- .3 ASHRAE-62.1: ANSI/ASHRAE-62.1-2016 Ventilation for Acceptable Indoor Air Quality, including User's Manual.
- .4 ASHRAE-90.1: ANSI/ASHRAE/IES-90.1-2016 Energy Standard for Buildings Except Low-Rise Residential, including User's Manual.
- .5 ASTM-A653: ASTM-A653/A653M-15 Standard Specification for Steel Sheet, Zinc Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.
- .6 ASTM-C534: ASTM-C534/C534M-16 Standard Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form.
- .7 ASTM-C553: ASTM-C553-15 Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications.
- .8 ASTM-C612: ASTM-C612-14 Standard Specification for Mineral Fiber Block and Board Thermal Insulation.
- .9 ASTM-C921: ASTM-C921-10 (R2015) Standard Practice for Determining the Properties of Jacketing Materials for Thermal Insulation.
- .10 CSA-B52: CSA-B52-13 Mechanical Refrigeration Code.
- .11 MICA-NISM: MICA National Commercial and Industrial Insulation Standards Manual, 2016 (8th Edition).
- .12 TIAC-BPG: TIAC Mechanical Insulation Best Practices Guide.
- .13 ULC-S102: CAN/ULC-S102-10 Surface Burning Characteristics of Building Materials and Assemblies.

1.3 DEFINITIONS

1.4 SUBMITTALS FOR ACTION

- .1 Product Data
 - .1 Manufacturer's printed product literature, specifications, and datasheets, including product characteristics, materials, finish, dimensions, clearances, performance criteria, certifications, options, and limitations.
 - .2 Include the following additional information:
 - .1 Capacity and efficiency, including full and part loading.
 - .2 Performance curves, including flow and resistance.
 - .3 Electrical, including schematics, ladder logic, wiring diagrams, control sequences.
 - .4 Required services, including utilities and distribution systems.
 - .5 Sound and vibration ratings.
 - .6 Certifications.
 - .3 Refrigerant Circuits Equipment
 - .1 Labelling and Documentation: CSA-B52 and ASHRAE-15 labelling and documentation.
 - .2 Ontario Operating Engineers Regulation compliance.
 - .3 Refrigerant relief valve types, quantities, ratings.
 - .4 Refrigeration Equipment
 - .1 Efficiency and part load efficiency (10-% through to 100-% of design capacity in 10-% increments) based on loads and applicable temperatures at 2 decimal places accuracy.

- .2 Efficiency and part load efficiency (25-% through to 100-% of design capacity in 25-% increments) based on loads and applicable temperatures at 2 decimal places accuracy.
- .3 Turndown ratio.
- .4 AHRI ratings.
- .5 Type of refrigerant used.
- .6 Fluid flows for both gas (air or other gas as applicable) and liquid (water or other liquid as applicable) for design condition, minimum and maximum.
- .2 Shop Drawings
 - .1 Schedule: List of products, including quantities, sizes, dimensions, locations.
 - .2 Layout and Interference Plans: Scaled sketches indicating clearances, interferences, and relocation of interfering services, components, objects, and structures.
 - .1 Drain Pan Layouts: Additional scaled sketches indicating materials, dimensions, slopes, connection points, construction of corners.
 - .3 Mounting: Details of product mounting, including foundation details with loadings, anchor bolt arrangements, roof curb details, point loads, roof structure details.
 - .4 Suspension Systems: Details of suspended products, including:
 - .1 Location of suspension.
 - .2 Maximum load at each of the suspension points.
 - .3 Size of suspension rods or members.
 - .4 Details of supplementary structural steel framing members.
 - .5 Vibration and seismic control measures.
 - .6 Electrical Power: Details of electrical power connections.
 - .7 Interlocks: Details of electrical interlocks and life safety system interfaces, including schematics, ladder logic, wiring diagrams, control sequences.
- .3 Demolition Plan: Details of demolition requirements, including manufacturer's certification, or lab reports describing the materials being cut into.

1.5 SUBMITTALS FOR INFORMATION

- .1 Certificates
 - .1 Equipment Start-up: Letter from manufacturer certifying:
 - .1 Start-up, installation, adjustments and testing has been executed in accordance with manufacturer's instructions and recommendations, and no warranty conditions have been violated.
 - .2 Equipment is performing in accordance with expectations.
 - .2 Vibration Hardware Installation: Letter from manufacturer certifying start-up and installation has been executed in accordance with manufacturer's recommendations and Contract Documents.
 - .3 Performance
 - .1 Letter certifying ASHRAE-90.1 compliance.
 - .2 Letter certifying ASHRAE-62.1 compliance.
 - .3 Documents on AHRI certification.
- .2 Delegated Professional Design Submittals
 - .1 Design and design documents completed by a professional engineer for the following:
 - .1 Mounting of equipment, services and components as installed does not exceed structural limits of structure, including seismic provisions of local building code. Engineered drawings and record drawings of existing installation may not be available or may not exist including design drawings, shop drawings.
 - .2 Mounting components and restraints are suitable for application and requirements, including seismic provisions of local building code.
- .3 Manufacturer Information
 - .1 Operating and Maintenance Manual
 - .2 Installation Instructions
 - .3 Users Manuals

- .4 Start-up Checklists
- .4 Test and Evaluation Reports
 - .1 Start-up Reports: Completed manufacturer's start-up checklists and notes.
 - .2 Electrical: Measurements for equipment when off and powered up, for power as well as voltage and current measurements for each phase.
 - .3 Testing and Balancing Reports
- .5 Qualification Statements
 - .1 Noise and Vibration: Proof of certifications for company personnel.
 - .2 TAB: Proof of certifications for company and personnel.
 - .3 Professional Engineering: Proof of licences for company and personnel.

1.6 SUBMITTALS FOR CLOSEOUT

- .1 Spare Parts
 - .1 Spare parts for 1 year of operation.
 - .2 Spare parts recommended by manufacturers.
- .2 Tools
 - .1 Special tools required for operation and maintenance.

1.7 QUALITY ASSURANCE

- .1 Qualifications
 - .1 Noise and Vibration Testing
 - .1 Company NEBB certified.
 - .2 Personnel to be NEBB Sound and Vibration Certified Professional.
 - .2 TAB
 - .1 Company and personnel members of AABC and CAABC, or NEBB.
 - .2 Company and personnel AABC or NEBB certified.
 - .3 Subject to approval.
 - .3 Professional Engineering
 - .1 Company and personnel licensed to practice Professional Engineering by PEO.
 - .2 Subject to approval.

PART 2 PRODUCTS

2.1 COMMON PRODUCT REQUIREMENTS

- .1 Efficiency Performance: Provide equipment to meet the more stringent requirements of as indicated or as follows:
 - .1 To ASHRAE-90.1.
- .2 Noise Performance: Provide equipment and services, including piping and ductwork, to meet the following requirements:
 - .1 Occupied Areas: Less than 35-N.C. Level.
 - .2 Service Areas: Less than 50-N.C. Level.
 - .3 Vibration created by mechanical equipment must be below the level of perception in occupied areas of the building.
- .3 Start-up Control Requirements
 - .1 For equipment capable of being powered by standby power, provide the following to limit total start-up current upon power failure:
 - .1 Soft start: Less than 200-% of full load current upon start-up.
 - .2 Random or pre-set start-up delay.
- .4 Ventilation Equipment
 - .1 To ASHRAE-62.1.

2.2 FANS - INLINE - CENTRIFUGAL

- .1 Provide as indicated.
- .2 Manufacturers
 - .1 Greenheck Fan Corporation, BSQ/SQ Series
- .3 Features
 - .1 Backward inclined centrifugal fan.

- .2 Permanent sealed bearings.
- .3 Grip notch belt.
- .4 Mounting brackets isolation.
- .5 Local disconnect switch rated for environment.
- .6 Duct collars.
- .7 Access panel.
- .8 Protective clear finish.
- .4 Options
 - .1 BDS - Belt Drive System
 - .1 Fan sheave.
 - .2 Adjustable motor sheave.
 - .5 Motors: To Section 26 00 00 Electrical Distribution.
 - .6 Materials
 - .1 Fan Wheel
 - .1 Aluminum construction.
 - .2 Housing
 - .1 Heavy gauge galvanized steel.
 - .7 Selection: Fans may be selected to operate into motor service factor on the run-out condition under the following conditions:
 - .1 For systems with variable frequency drives.
 - .2 For systems with adjustable electrical overloads.
 - .3 With review by Engineer.
 - .4 With proof of manufacturer warranty provided for selection.
 - .8 Substitution Limitations
 - .1 Substitutions may be accepted under substitution provisions described in Contract Documents.
 - .2 Substitutions may be limited by various requirements and may require re-design, including:
 - .1 Physical characteristics, including weight, height, length, width.
 - .2 Minimum and maximum airflows, maximum pressure drops, noise.
 - .3 Re-design differences as a result of substitution to Delegated Professional Design requirements described in Contract Documents.
 - .4 Acceptable Substitution Manufacturers
 - .1 JencoFan, SQB/SQD Series
 - .2 PennBarry, SX Series

2.3 FANS - INLINE - MIXED FLOW

- .1 Provide as indicated.
- .2 Manufacturers
 - .1 Greenheck Fan Corporation, EQB Series
- .3 Features
 - .1 Non-overloading, mixed flow wheel.
 - .2 Regreasable pillow block bearings.
 - .3 Extended lube lines.
 - .4 Grip notch belt.
 - .5 Mounting brackets isolation.
 - .6 Local disconnect switch rated for environment.
 - .7 Duct collars.
 - .8 Access panel.
 - .9 Protective clear finish.
- .4 Options
 - .1 BDS - Belt Drive System
 - .1 Fan sheave.
 - .2 Adjustable motor sheave.

- .5 Motors: To Section 26 00 00 Electrical Distribution.
- .6 Materials
 - .1 Fan Wheel
 - .1 Aluminum construction.
 - .2 Housing
 - .1 Heavy gauge galvanized steel.
- .7 Selection: Fans may be selected to operate into motor service factor on the run-out condition under the following conditions:
 - .1 For systems with variable frequency drives.
 - .2 For systems with adjustable electrical overloads.
 - .3 With review by Engineer.
 - .4 With proof of manufacturer warranty provided for selection.
- .8 Substitution Limitations
 - .1 Substitutions may be accepted under substitution provisions described in Contract Documents.
 - .2 Substitutions may be limited by various requirements and may require re-design, including:
 - .1 Physical characteristics, including weight, height, length, width.
 - .2 Minimum and maximum airflows, maximum pressure drops, noise.
 - .3 Re-design differences as a result of substitution to Delegated Professional Design requirements described in Contract Documents.
 - .4 Acceptable Substitution Manufacturers
 - .1 Cook, QMX Series
 - .2 PennBarry, ESI Series

2.4 VENTILATION UNIT - PACKAGED - MIXED AIR HEATING AND COOLING

- .1 Provide as indicated.
- .2 Manufacturers
 - .1 Daikin Applied, Rebel
- .3 Limitations: Specific limitations may be exceeded based on indicated requirements of Substitution Limitations below.
 - .1 Refrigerant Compressor Quantity: Refrigerant compressor quantity of 1.
 - .2 Refrigerant Circuit Quantity: Refrigerant circuit quantity of 1.
 - .3 Refrigerant Charge: Refrigerant charge per circuit to not exceed 36-kg (80-lb).
 - .4 Refrigerant Compressor Power: Refrigerant compressor power to be less than 11-kW.
 - .5 Refrigerant Piping: Refrigerant circuit piping to not be field modified, including requirements for controls, safeties and independent safeties, including during installation.
 - .1 Nominal Efficiency: To ASHRAE-90.1.
 - .6 Maximum Power: Power in kW units clearly identified on nameplate for compressor(s) power.
- .4 Refrigeration Compressor
 - .1 Type
 - .1 Direct drive hermetically sealed digital scroll compressors.
 - .2 Inverter scroll.
 - .2 Quantity: 1.
 - .3 Refrigerant Circuits: 1
 - .4 Refrigerant Type: High pressure refrigerant, R-410A.
 - .5 Compressor Cooling: Compressors are cooled by refrigerant on the suction side.
 - .6 Options: Provide the following:
 - .1 Direct drive ECM condenser fans with vertical discharge and heavy gauge steel fan guards.
 - .2 Sound: Compressor sound blankets.
 - .3 Mounting: Springs.

- .4 Refrigerant Control
 - .1 Electronic expansion valve, adjustable, external equalizer.
 - .2 High and low refrigerant pressure switches.
- .5 Refrigerant Piping Components
 - .1 Liquid line filter drier.
 - .2 Sight glass and moisture indicator.
 - .3 Service gauge ports.
- .6 Electrical
 - .1 Circuit breaker per compressor.
 - .2 Externally mounted disconnect switch.
 - .3 Access panels gasketed, hinged with lockable handles.
 - .4 External emergency stop contacts.
- .7 Electronic Controls
 - .1 Low refrigerant temperature or pressure alarms.
 - .2 High refrigerant temperature or pressure alarms.
 - .3 Electrical input fault alarms.
 - .4 Local emergency stop.
- .7 Performance
 - .1 AHRI certified.
 - .2 Nominal Rating: As indicated.
 - .3 Nominal Efficiency: As indicated.
 - .4 Maximum Power: Power less than 11-kW clearly identified on nameplate for compressor(s) power.
 - .5 Standard Conditions Ratings: To standard conditions of AHRI-550-590.
 - .6 Design Conditions Ratings: As required by coils.
- .5 Refrigerant Coils
 - .1 Type
 - .1 Energy transfer between refrigerant and air stream.
 - .2 Coil with tubes and fins for heat exchanger surfaces.
 - .3 Rated for refrigerant type, temperatures, pressures, phase change.
 - .2 Construction: Single unit constructed. Field assembly or disassembly is prohibited.
 - .3 Mounting: Integral to air handler cabinet.
 - .4 Materials
 - .1 Copper tube and aluminum fin coil.
 - .2 Galvanized steel frame and mounting structure.
 - .5 Performance
 - .1 Air Velocity
 - .1 Maximum 2.0-m/s (400-fpm) in both supply and exhaust air streams.
 - .2 Minimum as required to prevent freezing.
 - .6 Maximum Power: Power less than 11-kW clearly identified on nameplate for compressor(s) power.
- .6 Heating
 - .1 Provide as indicated.
 - .2 Type
 - .1 Electric resistance heating section.
 - .3 Construction
 - .1 Full line-breaking electrical contactors.
 - .2 Individually fused branch circuits.
 - .3 Primary high temperature limit with automatic reset.
 - .4 Secondary high temperature limit with manual reset.
 - .4 Mounting: Integral to air handler cabinet.
 - .5 Materials
 - .1 Nickel-chromium alloy.

- .6 Performance
 - .1 As indicated.
 - .2 Stages: 2.
- .7 Dampers
 - .1 To Section 23 30 00 Ductwork.
 - .2 Motorized outdoor air damper and actuator.
- .8 Supply Fan
 - .1 Type
 - .1 Centrifugal, forward inclined AMCA rated and certified.
 - .2 Construction
 - .1 Dynamically balanced pulleys.
 - .2 Variable pitch motor sheaves for fan speed adjustment.
 - .3 Mounting: Integral to air handler cabinet.
 - .4 Materials
 - .1 Galvanized steel blower wheel.
 - .2 Solid steel shafts.
 - .3 Galvanized steel pulleys.
 - .5 Motors
 - .1 To Section 26 00 00 Electrical Distribution.
 - .2 Speed: As required.
 - .3 Electrical Power: As indicated.
 - .6 Performance
 - .1 Air flow and external static pressure as indicated.
 - .2 Internal static pressure as required to maintain air flow through internal components.
 - .3 Minimum 60-% fan static efficiency.
- .9 Powered Exhaust Fan
 - .1 Type
 - .1 As required.
 - .2 SWSI, Centrifugal, forward inclined AMCA rated and certified.
 - .2 Mounting: Integral to air handler cabinet.
 - .3 Materials
 - .1 Galvanized steel blower wheel.
 - .2 Solid steel shafts.
 - .3 Galvanized steel pulleys.
 - .4 Motors
 - .1 To Section 26 00 00 Electrical Distribution.
 - .2 Type: As indicated.
 - .3 Speed: As required.
 - .4 Electrical Power: As indicated.
 - .5 Performance
 - .1 As required.
- .10 Cabinet
 - .1 Dimensions: As indicated, otherwise as required.
 - .2 Construction
 - .1 Unitary 1-piece construction, mounted on base rails of galvanized steel.
 - .2 Frame construction consisting of integral galvanized steel vertical and horizontal structural members.
 - .3 Frame construction to allow complete removal of wall and top panels without affecting structural integrity of the unit.
 - .4 Equipped with reinforcing cross-members as required for lifting.
 - .5 Base rail channels to support all components and service requirements.

- .6 Indoor blower section to be insulated with minimum 50-mm (2-in) thick insulation.
- .7 Heating and higher temperature sections to be provided with aluminum foil faced insulation.
- .8 Suitable for modifications including penetrations for services.
- .3 Materials
 - .1 Cabinet Exterior: Minimum 1.2-mm (18-ga) thick galvanized steel.
 - .2 Cabinet Floor Panels: Minimum 1.2-mm (18-ga) thick galvanized steel with Z270 (G90) finish to ASTM-A653.
 - .3 Cabinet Interior Liner: Minimum 1.2-mm (18-ga) thick galvanized steel with Z270 (G90) finish to ASTM-A653.
- .4 Features
 - .1 Drain Pan
 - .1 150-mm (3-in) high drain pan from outdoor air intake to past heating section and sloped to opposite corners with 19-mm (3/4-in) drain ports.
 - .2 Filters
 - .1 Permanent mounting rack for filters.
 - .2 100-mm (2-in) MERV 8 thick fiberglass disposable pre-filters.
 - .3 100-mm (4-in) MERV 8 thick fiberglass disposable final-filters.
 - .4 Rated for minimum 3.0-m/s (600-fpm) air velocity.
 - .3 Economizer hood with bird screen.
 - .4 Doors
 - .1 Provide access doors to filter sections, fan sections, control panel section, heating section other serviceable components.
 - .2 Continuously hinged, stainless steel hinges.
 - .3 Capable of opening 180-degrees with hold open devices.
 - .4 Minimum 2 half turn latches per door.
 - .5 Completely gasketed with compressible reinforced single piece vinyl gasket.
- .11 Roof Curb
 - .1 Type
 - .1 Full perimeter type, pre-fabricated.
 - .2 Min 14-in high.
 - .3 Insulated.
 - .2 Materials
 - .1 Galvanized steel.
 - .3 Accessories
 - .1 Wood nailing strip.
 - .2 Gasket.
- .12 Electrical
 - .1 Externally mounted disconnect switch.
 - .2 Convenience 120-VAC power receptacle mounted inside control panel, powered by separate circuit.
 - .3 Access panels gasketed, hinged with lockable handles.
- .13 Controls
 - .1 Air handling unit independent controller, including the following:
 - .1 Local programmable zone temperature control with digital display to allow adjustment of scheduling, settings.
 - .2 Variable speed supply fan control.
 - .3 Variable speed exhaust fan control.
 - .4 Proportional outdoor air damper reset.
 - .5 Fixed dry bulb temperature airside economizer.
 - .6 Condenser head pressure control.
 - .7 Compressor envelope control.

- .8 BACnet panel, BTL listed, as required to fully interface with building automation system using BACnet.
- .9 Controller to be of same manufacturer as ventilation unit.
- .14 Substitution Limitations
 - .1 Substitutions may be accepted under substitution provisions described in Contract Documents.
 - .2 Substitutions may require re-design of services including piping, ductwork, venting, structural, power, and controls.
 - .3 Substitutions may be limited by requirements of:
 - .1 Physical characteristics, including weight, height, length, width.
 - .2 Structural work required, including resupport of roof.
 - .4 Pay for all re-design and cost increases resulting from substitution in accordance with Contract Documents including conditions and procedures.
 - .5 Acceptable Substitution Manufacturers
 - .1 Johnson Controls Inc.
 - .2 Trane Inc., Voyager

2.5 VENTILATION UNIT - PACKAGED - MIXED AIR COOLING ONLY

- .1 Provide as indicated.
- .2 Manufacturers
 - .1 Daikin Applied, Rebel
- .3 Limitations: Specific limitations may be exceeded based on indicated requirements of Substitution Limitations below.
 - .1 Refrigerant Compressor Quantity: Refrigerant compressor quantity of 2 or 3.
 - .2 Refrigerant Circuit Quantity: Refrigerant circuit quantity of 2.
 - .3 Refrigerant Charge: Refrigerant charge per circuit to not exceed 36-kg (80-lb).
 - .4 Refrigerant Compressor Power: Refrigerant compressor power to be less than 11-kW.
 - .5 Refrigerant Piping: Refrigerant circuit piping to not be field modified, including requirements for controls, safeties and independent safeties, including during installation.
 - .1 Nominal Efficiency: To ASHRAE-90.1.
 - .6 Maximum Power: Power in kW units clearly identified on nameplate for compressor(s) power.
- .4 Refrigeration Compressor
 - .1 Type
 - .1 Direct drive hermetically sealed digital scroll compressors.
 - .2 Inverter scroll.
 - .2 Quantity: 1.
 - .3 Stages: 1
 - .4 Refrigerant Circuits: 1
 - .5 Refrigerant Type: High pressure refrigerant, R-410A.
 - .6 Compressor Cooling: Compressors are cooled by refrigerant on the suction side.
 - .7 Options: Provide the following:
 - .1 Direct drive ECM condenser fans with vertical discharge and heavy gauge steel fan guards.
 - .2 Sound: Compressor sound blankets.
 - .3 Mounting: Springs.
 - .4 Refrigerant Control
 - .1 Electronic expansion valve, adjustable, external equalizer.
 - .2 High and low refrigerant pressure switches.
 - .5 Refrigerant Piping Components
 - .1 Liquid line filter drier.
 - .2 Sight glass and moisture indicator.
 - .3 Service gauge ports.

- .6 Electrical
 - .1 Circuit breaker per compressor.
 - .2 Externally mounted disconnect switch.
 - .3 Access panels gasketed, hinged with lockable handles.
 - .4 External emergency stop contacts.
- .7 Electronic Controls
 - .1 Low refrigerant temperature or pressure alarms.
 - .2 High refrigerant temperature or pressure alarms.
 - .3 Electrical input fault alarms.
 - .4 Local emergency stop.
- .8 Performance
 - .1 AHRI certified.
 - .2 Nominal Rating: As indicated.
 - .3 Nominal Efficiency: As indicated.
 - .4 Maximum Power: Power less than 11-kW clearly identified on nameplate for compressor(s) power.
 - .5 Standard Conditions Ratings: To standard conditions of AHRI-550-590.
 - .6 Design Conditions Ratings: As required by coils.
- .5 Refrigerant Coils
 - .1 Type
 - .1 Energy transfer between refrigerant and air stream.
 - .2 Coil with tubes and fins for heat exchanger surfaces.
 - .3 Rated for refrigerant type, temperatures, pressures, phase change.
 - .2 Construction: Single unit constructed. Field assembly or disassembly is prohibited.
 - .3 Mounting: Integral to air handler cabinet.
 - .4 Materials
 - .1 Copper tube and aluminum fin coil.
 - .2 Galvanized steel frame and mounting structure.
 - .5 Performance
 - .1 Air Velocity
 - .1 Maximum 2.0-m/s (400-fpm) in both supply and exhaust air streams.
 - .2 Minimum as required to prevent freezing.
 - .6 Maximum Power: Power less than 11-kW clearly identified on nameplate for compressor(s) power.
- .6 Dampers
 - .1 To Section 23 30 00 Ductwork.
 - .2 Motorized outdoor air damper and actuator.
- .7 Supply Fan
 - .1 Type
 - .1 Centrifugal, forward inclined AMCA rated and certified.
 - .2 Construction
 - .1 Dynamically balanced pulleys.
 - .2 Variable pitch motor sheaves for fan speed adjustment.
 - .3 Mounting: Integral to air handler cabinet.
 - .4 Materials
 - .1 Galvanized steel blower wheel.
 - .2 Solid steel shafts.
 - .3 Galvanized steel pulleys.
 - .5 Motors
 - .1 To Section 26 00 00 Electrical Distribution.
 - .2 Speed: As required.
 - .3 Electrical Power: As indicated.
 - .6 Performance

- .1 Air flow and external static pressure as indicated.
- .2 Internal static pressure as required to maintain air flow through internal components.
- .3 Minimum 60-% fan static efficiency.
- .8 Cabinet
 - .1 Dimensions: As indicated, otherwise as required.
 - .2 Construction
 - .1 Unitary 1-piece construction, mounted on base rails of galvanized steel.
 - .2 Frame construction consisting of integral galvanized steel vertical and horizontal structural members.
 - .3 Frame construction to allow complete removal of wall and top panels without affecting structural integrity of the unit.
 - .4 Equipped with reinforcing cross-members as required for lifting.
 - .5 Base rail channels to support all components and service requirements.
 - .6 Indoor blower section to be insulated with minimum 50-mm (2-in) thick insulation.
 - .7 Heating and higher temperature sections to be provided with aluminum foil faced insulation.
 - .8 Suitable for modifications including penetrations for services.
 - .3 Materials
 - .1 Cabinet Exterior: Minimum 1.2-mm (18-ga) thick galvanized steel. Painted.
 - .2 Cabinet Floor Panels: Minimum 1.2-mm (18-ga) thick galvanized steel with Z270 (G90) finish to ASTM-A653.
 - .3 Cabinet Interior Liner: Minimum 1.2-mm (18-ga) thick galvanized steel with Z270 (G90) finish to ASTM-A653.
 - .4 Features
 - .1 Drain Pan
 - .1 150-mm (3-in) high drain pan from outdoor air intake to past heating section and sloped to opposite corners with 19-mm (3/4-in) drain ports.
 - .2 Filters
 - .1 Permanent mounting rack for filters.
 - .2 100-mm (2-in) MERV 8 thick fiberglass disposable pre-filters.
 - .3 100-mm (4-in) MERV 8 thick fiberglass disposable final-filters.
 - .4 Rated for minimum 3.0-m/s (600-fpm) air velocity.
 - .3 Economizer hood with bird screen.
 - .4 Doors
 - .1 Provide access doors to filter sections, fan sections, control panel section, heating section other serviceable components.
 - .2 Continuously hinged, stainless steel hinges.
 - .3 Capable of opening 180-degrees with hold open devices.
 - .4 Minimum 2 half turn latches per door.
 - .5 Completely gasketed with compressible reinforced single piece vinyl gasket.
- .9 Roof Curb
 - .1 Type
 - .1 Full perimeter type, pre-fabricated.
 - .2 Min 14-in high.
 - .3 Insulated.
 - .2 Materials
 - .1 Galvanized steel.
 - .3 Accessories
 - .1 Wood nailing strip.
 - .2 Gasket.
- .10 Electrical

- .1 Externally mounted disconnect switch.
- .2 Convenience 120-VAC power receptacle mounted inside control panel, powered by separate circuit.
- .3 Access panels gasketed, hinged with lockable handles.
- .11 Controls
 - .1 Air handling unit independent controller, including the following:
 - .1 Local programmable zone temperature control with digital display to allow adjustment of scheduling, settings.
 - .2 Variable speed supply fan control.
 - .3 Discharge air pressure control.
 - .4 Proportional outdoor air damper reset.
 - .5 Fixed dry bulb temperature airside economizer.
 - .6 Condenser head pressure control.
 - .7 Compressor envelope control.
 - .8 BACnet panel, BTL listed, as required to fully interface with building automation system using BACnet.
 - .9 Controller to be of same manufacturer as ventilation unit.
- .12 Substitution Limitations
 - .1 Substitutions may be accepted under substitution provisions described in Contract Documents.
 - .2 Substitutions may require re-design of services including piping, ductwork, venting, structural, power, and controls.
 - .3 Substitutions may be limited by requirements of:
 - .1 Physical characteristics, including weight, height, length, width.
 - .2 Structural work required, including resupport of roof.
 - .4 Pay for all re-design and cost increases resulting from substitution in accordance with Contract Documents including conditions and procedures.
 - .5 Acceptable Substitution Manufacturers
 - .1 Johnson Controls Inc.
 - .2 Trane Inc., Voyager

2.6 NOISE AND VIBRATION CONTROL

- .1 Provide noise and vibration control hardware supplied by a single supplier.

2.7 EQUIPMENT MOUNTING

- .1 Provide mounting including frames, supports, pads and curbs as required.

2.8 EQUIPMENT INSULATION

- .1 Provide insulation on equipment as indicated.
- .2 Provide adhesive, tape, sealants, cement, and mastic as recommended by, and compatible with, insulation and insulation jacket manufacturers.
- .3 Common Performance Requirements
 - .1 Flame-Spread: Maximum 25 tested to ULC-S102.
 - .2 Smoke Developed: Maximum 50 tested to ULC-S102.
- .4 Type MF - Preformed Mineral Fibre
 - .1 Manufacturers
 - .1 Owens Corning Canada Inc., Fiberglass 700 Series
 - .2 Manson Insulation Products, AK Board or AK Flex
 - .2 To ASTM-C553 or ASTM-C612 as required.
- .5 Type EF - Flexible Elastomeric Foam
 - .1 Manufacturers
 - .1 Thickness not greater than 1-in: Armacell LLC, AP Armaflex
 - .2 Thickness greater than 1-in: Armacell LLC, AP Armaflex FS
 - .2 To ASTM-C534.

2.9 JACKETS

- .1 Provide jackets around insulated equipment unless otherwise indicated.
- .2 Common Performance Requirements
 - .1 Flame-Spread: Maximum 25 tested to ULC-S102.
 - .2 Smoke Developed: Maximum 50 tested to ULC-S102.
- .3 Type CAN - Canvas Jacket
 - .1 Provide as required.
 - .2 ULC Listed.
 - .3 Fabric: ASTM-C921, 220-g/m² (6-oz/yd²), plain weave cotton treated with dilute fire retardant lagging adhesive.

PART 3 EXECUTION

3.1 EXAMINATION

- .1 Pre-Installation Pressure Test
 - .1 Prior to installation, pressure test existing system in its entirety to identify deficiencies in existing piping.
 - .1 Identify and report on all pressure relief devices and equipment maximum pressure ratings.
 - .2 Increase system pressure by 25-psi until target pressure is reached. Target pressure as determined by Engineer, including maximum operating pressure, design limit pressure.
 - .3 Maintain system pressure for minimum 4-hour duration.
 - .4 Inspect piping connections, seals, and equipment for leaks.
 - .5 If there are no leaks, repeat above steps until pressure reaches target pressure.
 - .6 If there are leaks, report on findings, allow minimum 10-days for Owner to repair, repeat above until pressure reaches target pressure.
 - .2 Verification of Conditions
 - .1 Confirm all dimensions indicated.
 - .2 Ensure clearances and maintenance access to equipment meet or exceed manufacturer's recommendations. Notify Engineer of problems.
 - .3 Investigate required relocation of objects to prevent interference. Submit interference drawings as required.
 - .4 Investigate wall construction for structural members, hazardous material, and building and utility services before opening.
 - .3 Evaluation and Assessment
 - .1 Evaluate condition of equipment before Work. Report deficiencies to Engineer.
 - .2 Review proposed retrofits with manufacturers.

3.2 COMMON EXECUTION REQUIREMENTS

- .1 Provide equipment with identification as indicated. Nameplates to match quality and style of existing.
- .2 Provide services, including electrical, to equipment as required.
- .3 Insulate equipment as indicated and as required where not indicated
- .4 Replace services around equipment to fit equipment and to suit equipment requirements, including piping, ductwork, venting, wiring.
- .5 Install products in locations providing appropriate ambient conditions for its operation, and allowing for adequate ventilation.
- .6 Provide clearances around systems, equipment and components for inspection, servicing and maintenance and as required. Minimum clearance of 300-mm (1-ft).
- .7 Provide clearances around products to prevent interference with adjacent systems, equipment and components.
- .8 Provide valves and either unions or flanges to connect piping to equipment for ease of maintenance and assembly.

- .9 Support equipment such that no loads are transmitted to services including piping, ductwork, venting, wiring.
- .10 Noise and Vibration Control
 - .1 Install vibration control hardware in accordance with manufacturer's instructions (and supervision where required) and only by workmen experienced in the installation of such systems.
 - .2 Replace isolation pads, and modify supports as required to mitigate vibration and noise to Owner's satisfaction.
- .11 Provide equipment safeties and interlocks as required.
- .12 Manufacturer Services
 - .1 Supervision: Manufacturer to supervise field assembly of equipment to ensure warranty and performance provisions are met.
 - .2 Start-up: Manufacturer to approve installation, to supervise start-up, and to instruct Owner, unless otherwise indicated.
 - .3 Adjusting: Adjust for optimal performance, under manufacturer supervision.

3.3 EQUIPMENT MOUNTING

- .1 Intent: Contractor responsibility as requirements depends in part on final selection and installation location.
- .2 Design mounting including frames, supports and curbs as required where not indicated.
- .3 Support equipment such that no loads are transmitted to services including piping, ductwork, venting, wiring.
- .4 Provide concrete housekeeping pads for base-mounted equipment.
 - .1 Size: Minimum 100-mm (4-in) high, larger in width and depth by 75-mm (3-in).
- .5 Provide stands for equipment that can be wall mounted but are not located on walls unless otherwise indicated. Anchor bolt to surfaces.
- .6 Performance: Design equipment mounting:
 - .1 To make equipment level.
 - .2 To protect equipment from water damage.
 - .3 To withstand seismic events with seismic restraint as required.
 - .4 To minimize noise and vibration transmitted to services and building structure.
 - .5 To withstand concentrated loads of 2-kN (450-lbf) applied at any point in any direction.

3.4 FANS

- .1 Install as required.

3.5 VENTILATION UNITS

- .1 Install as required.
- .2 Modifications: Manufacturer to review and approve methods for modifications including cabinet penetrations for services.
- .3 Start-up: Manufacturer to complete start-up.

3.6 EQUIPMENT INSULATION AND JACKETS

- .1 Replace insulation and jackets on existing equipment as indicated.
- .2 Replace damaged insulation and jackets on existing equipment affected by Work.
- .3 Insulate equipment including jackets where not indicated as follows:
 - .1 At risk of condensation, including vapour barrier.
 - .2 With surface temperatures greater than 50-°C (120-°F).
 - .3 With surface temperatures greater than 35-°C (63-°F) delta temperature compared to surrounding conditions.
 - .4 As required to ASHRAE-90.1.
- .4 Install insulation, and seal seams and joints to prevent corrosion of equipment surface by condensation or precipitation.
- .5 Install to:
 - .1 MICA-NISM.

- .2 TIAC-BPG.
- .6 Maintain continuity and integrity of vapour retarder jacket and finishes to prevent corrosion of equipment surface by condensation or precipitation.
- .7 Insulated Components
 - .1 Provide removable insulation to serviceable components and devices, including nameplates, access hatches and doors, drains, measurement ports, operable components.
 - .1 For smaller removable insulation, use insulation with same or better thermal performance but a type that can be installed with tight fitting friction fits
 - .2 Provide labels on covered components and devices.
- .8 Seams
 - .1 Seal seams using seam sealant acceptable to manufacturer and Engineer.
 - .2 Match seam sealant to jacket.
 - .3 Minimize the number of seams by using full length insulation pieces.
 - .4 Position overlaps to shed water.
 - .5 Locate longitudinal seams at the side of equipment that is least visible.
- .9 Supports and Hangers
 - .1 Install supports and hangers outside vapour retarder jacket.
 - .2 Install high compressive strength insulation under equipment supports to prevent compression of insulation.
- .10 Additional Finishing
 - .1 Type CAN - Canvas Jacket: Paint jackets.

3.7 FIELD QUALITY CONTROL

- .1 Field Tests
 - .1 Complete TAB, and submit report.
- .2 Field Inspections
 - .1 Submit report from vibration control hardware supplier certifying that the installation has been carried out in accordance with manufacturer's recommendations.
- .3 Non-Conforming Work
 - .1 Provide sound and vibration test report upon request for non-conforming area.
 - .2 Re-fabricate and re-install any installation of equipment, piping, and ductwork judged by Engineer to be unsound or poor with regard to the sound and vibration requirements.
- .4 Manufacturer Services
 - .1 Complete required tests on equipment.
 - .2 Complete combustion tests on equipment.
- .5 Fluid Level, Low Fluid, Flow Sensors and Switches
 - .1 Set and coordinate settings with requirements of system and other flow devices including pumps and control valves.
 - .2 Allow for 4 additional site visits after start-up and during Warranty Period for adjustments to flow sensors and switches during system operation and shutdown to achieve desired operation under various conditions including peak and seasonal loads.

3.8 LABELLING AND DOCUMENTATION

- .1 Nameplates: Affix manufacturer's nameplates to equipment in a readily visible location.
- .2 Identification: Provide lamacoid nameplates for identification on each enclosure, panel, or field equipment, including existing.
 - .1 Construction: Laminated plastic with a different coloured core and engraved lettering to clearly show lettering with style as follows, unless otherwise specified:
 - .1 Style: Capital letters, minimum 12-mm (1/2-in) high, equal character spacing, centered (not justified).
 - .2 Colours: Colours of letters and background may change for each type of equipment or component. Provide colours to Owner requirements, otherwise provide white letters and black background.
 - .3 Warning: Install warning labels as required, including:

- .1 Warning of automatic control.
- .2 Warning of safety related matters.
- .3 Warning of restricted access by authorized and/or qualified personnel.
- .4 Warning of implications related to breaking means of restricting access including seals.
- .4 Refrigeration System Marking and Labelling
 - .1 Provide marking and labelling to CSA-B52 and ASHRAE-15, including:
 - .1 Signs, nameplates and instructions as required by CSA-B52, Article 5.11.
 - .2 Multiple sets of instructions for equipment of any size to CSA-B52, Article 5.11.5 to be posted at:
 - .1 Locations identified in CSA-B52, Article 5.11.5.
 - .2 Refrigeration equipment room main entrance as determined by Owner.
 - .3 Owner's preferred maintenance office.
 - .5 Ceiling Labelling
 - .1 Provide coloured labels on ceiling surfaces to indicate equipment and components including the following. Colours indicated are indicative of requirements and Owner may change for each type of equipment or component.
 - .2 Provide labels as acceptable to Owner, including label type, material, size and colour. Owner may require lamacoids, adhesive labels with text, adhesive labels with no text.
 - .3 Mark each label as acceptable to Owner, including equipment label, type, power circuit.

3.9 START-UP

- .1 Provide the services of a qualified factory-trained manufacturer's representative to assist with installation and start-up.
 - .1 Submit manufacturer's start-up report, and written certification that the equipment has been installed, adjusted and tested in accordance with the manufacturer's recommendations.

3.10 ADJUSTING

- .1 Adjusting: Adjust settings as required before Total Performance and throughout Warranty Period to address performance issues, including safeties, operating limits, noise, vibration, efficiency, equipment longevity.

END OF SECTION 23 00 00

SECTION 23 05 15 COMMON PIPING

PART 1 GENERAL

1.1 SECTION INCLUDES

- .1 Fluid piping and systems, water piping, closed and open loop systems, heating, service water systems, drain piping.
- .2 Piping and piping components including components fittings, connectors, supports, valves, vents, drains, gauges, regulators.

1.2 REFERENCED DOCUMENTS

- .1 AABC-TBP: AABC Test and Balance Procedures.
- .2 AABC-TSB: AABC National Standards for Total System Balance, 2016.
- .3 ASME-A13.1: ASME-A13.1-2015 Scheme for the Identification of Piping Systems.
- .4 ASME-B16.1: ASME-B16.1-2015 Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250.
- .5 ASME-B16.3: ASME-B16.3-2011 Malleable Iron Threaded Fittings: Classes 150 and 300.
- .6 ASME-B16.5: ASME-B16.5-2013 Pipe Flanges and Flanged Fittings: NPS 1/2 through NPS 24 Metric/Inch Standard.
- .7 ASME-B16.9: ASME-B16.9-2012 Factory-Made Wrought Buttwelding Fittings.
- .8 ASME-B16.15: ASME-B16.15-2013 Cast Copper Alloy Threaded Fittings: Classes 125 and 250.
- .9 ASME-B16.18: ASME-B16.18-2012 Cast Copper Alloy Solder Joint Pressure Fittings.
- .10 ASME-B16.22: ASME-B16.22-2013 Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings.
- .11 ASME-B16.24: ASME-B16.24-2016 Cast Copper Alloy Pipe Flanges and Flanged Fittings: Classes 150, 300, 600, 900, 1500, and 2500.
- .12 ASME-B18.2.1: ASME-B18.2.1-2012 Square, Hex, Heavy Hex, and Askew Head Bolts and Hex, Heavy Hex, Hex Flange, Lobed Head, and Lag Screws (Inch Series).
- .13 ASME-B31.9: ASME-B31.9-2014 Building Services Piping.
- .14 ASME-B40.100: ANSI/ASME-B40.100-2013 Pressure Gauges and Gauge Attachments.
- .15 ASTM-A47: ASTM-A47/A47M-99 (2014) Standard Specification for Ferritic Malleable Iron Castings.
- .16 ASTM-A53: ASTM-A53/A53M-12 Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc Coated Welded and Seamless.
- .17 ASTM-A312: ASTM-A312/A312M-16 Standard Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes.
- .18 ASTM-B32: ASTM-B32-08 (R2014) Standard Specification for Solder Metal.
- .19 ASTM-B88: ASTM-B88-16 Standard Specification for Seamless Copper Water Tube.
- .20 ASTM-B209: ASTM-B209-14 Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.
- .21 ASTM-B813: ASTM-B813-16 Standard Specification for Liquid and Paste Fluxes for Soldering of Copper and Copper Alloy Tube.
- .22 ASTM-B828: ASTM-B828-16 Standard Practice for Making Capillary Joints by Soldering of Copper and Copper Alloy Tube and Fittings.
- .23 ASTM-C534: ASTM-C534/C534M-16 Standard Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form.
- .24 ASTM-C547: ASTM-C547-15 Specification for Mineral Fiber Preformed Pipe Insulation.
- .25 ASTM-C585: ASTM-C585-10 (R2016) Standard Practice for Inner and Outer Diameters of Thermal Insulation for Nominal Sizes of Pipe and Tubing.
- .26 ASTM-C921: ASTM-C921-10 (R2015) Standard Practice for Determining the Properties of Jacketing Materials for Thermal Insulation.
- .27 ASTM-C1136: ASTM-C1136-16 Standard Specification for Flexible, Low Permeance Vapor Retarders for Thermal Insulation.

- .28 ASTM-E96: ASTM-E96/E96M-16 Standard Test Methods for Water Vapor Transmission of Materials.
- .29 AWS-A5.8: ANSI/AWS-A5.8/A5.8M-2011 Specification for Filler Metals for Brazing and Brazed Welding.
- .30 CGSB-24.3: CAN/CGSB-24.3-92 Identification of Piping Systems.
- .31 CGSB-51.53: CAN/CGSB-51.53-95 Jacketing, Polyvinyl Chloride Sheet, for Insulating Pipes, Vessels, and Round Ducts.
- .32 CSA-B51: CSA-B51-14 Boiler, Pressure Vessel, and Pressure Piping Code.
- .33 CSA-B214: CAN/CSA-B214-16 Installation Code for Hydronic Heating Systems, including CHC Handbook on Hydronic Heating Systems.
- .34 CSA-C22.2-60529: CAN/CSA-C22.2-60529-16 Degrees of Protection Provided by Enclosures (IP Code).
- .35 CSA-O80: CSA-O80-Series-15 Wood Preservation.
- .36 CSA-W47.1: CSA-W47.1-09 (R2014) Certification of Companies for Fusion Welding of Steel.
- .37 CSA-W47.2: CSA-W47.2-11 (R2015) Certification of Companies for Fusion Welding of Aluminum.
- .38 CSA-W48: CSA-W48-14 Filler Metals and Allied Materials for Metal Arc Welding.
- .39 CSA-W59: CSA-W59-13 Welded Steel Construction (Metal Arc Welding).
- .40 ISO-14726: ISO-14726-2008 Ships and Marine Technology - Identification Colours for the Content of Piping Systems.
- .41 MICA-NISM: MICA National Commercial and Industrial Insulation Standards Manual, 2016 (8th Edition).
- .42 NEBB-TABES: NEBB Procedural Standards for Testing, Adjusting, Balancing of Environmental Systems, 2015 (8th Edition).
- .43 NEMA-Z535.1: ANSI/NEMA-Z535.1-2006 (R2011) Safety Colors.
- .44 NFPA-90A: NFPA-90A-15 Standard for the Installation of Air-Conditioning and Ventilating Systems.
- .45 NFPA-90B: NFPA-90B-15 Standard for the Installation of Warm Air Heating and Air-Conditioning Systems.
- .46 TIAC-BPG: TIAC Mechanical Insulation Best Practices Guide.
- .47 ULC-S102: CAN/ULC-S102-10 Surface Burning Characteristics of Building Materials and Assemblies.
- .48 ULC-S115: CAN/ULC-S115-11 (R2016) Standard Method of Fire Tests of Firestop Systems.

1.3 DEFINITIONS

- .1 "DN": Diameter Nominal (Metric)

1.4 SUBMITTALS FOR ACTION

- .1 Product Data
 - .1 Manufacturers' product literature, specifications, and datasheets. Include product characteristics, performance criteria, options, and limitations.
- .2 Shop Drawings
 - .1 Piping Routing
 - .1 Layout and Interference Plans: Isometric sketches indicating clearances, interferences, and relocation of interfering services, components, objects, and structures.
 - .2 Fire Separations: Location of penetrations through fire separations and other assemblies.
 - .3 Pipe Drainage: Indicate details of piping slope angles and drainage where applicable.
 - .4 Expansion Compensation: Location of piping expansion control measures.
 - .5 Vibration Isolation: Location of vibration isolation connectors.
 - .6 Ports and Thermowells: Location of ports and thermowells.

- .2 Mounting: Details of bases, hangers, and supports.
- .3 Fire Stopping and Smoke Seals
 - .1 Locations and types marked on plan drawing.
 - .2 ULC assembly number certification.
 - .3 Required temperature rise and flame rating.
 - .4 Hose stream rating where applicable.
 - .5 Materials of fire stopping and smoke seals, primers, reinforcements, damming materials, reinforcements, and anchorages/fastenings.
 - .6 Assembly and penetration type and required ratings, adjacent materials.
 - .7 Openings size, thickness, dimensions.
 - .8 Proposed installation methods.
 - .9 Summaries of similar types of penetrations, assembly type and construction, service penetrating assembly, adjacent materials, fire stopping and smoke seal type, ratings, other work required.
 - .10 Copies of ULC certifications for proposed systems and designs for specific devices and materials.
 - .11 Image of sample tag.
- .4 Labels: Scaled drawings indicating label types, dimensions, layout, locations, wording, font, spacing, colours. Specifically identify letter sizes larger than indicated minimum heights.

1.5 SUBMITTALS FOR INFORMATION

- .1 Certificates
 - .1 Letter certifying piping support as installed has been designed and installed in compliance with required seismic restraint provisions.
 - .2 Letter certifying that materials comply with specified performance characteristics and physical properties.
 - .3 Letter from piping support manufacturer certifying pipe support systems have been installed in compliance with Contract Documents.
 - .4 Letter from fire stopping and smoke seals installer certifying that fire stopping and smoke seals have been installed in accordance with regulatory requirements and Contract Documents.
- .2 Manufacturer Information
 - .1 Fluid Treatment: Submit written operating instructions on treatment dosages, control charts and test procedures.
- .3 Balancing Reports
 - .1 Balancing Reports compliant with AABC-TBP and AABC-TSB, NEBB-TABES recommendations.
 - .2 Pressure Test Reports compliant with AABC-TBP and AABC-TSB, NEBB-TABES recommendations.
- .4 Qualification Statements
 - .1 Welding: Proof of certifications for company and personnel.
 - .2 TAB: Proof of certifications for company and personnel.
- .5 Documentation
 - .1 Shutoff valve charts.
- .6 Other/Photographs
 - .1 Required photographs.

1.6 QUALITY ASSURANCE

- .1 Qualifications
 - .1 Welding
 - .1 Company certified by CWB to CSA-W47.1 and CSA-W47.2.
 - .2 Personnel to have welding qualifications to CSA-B51.
 - .2 TAB
 - .1 Company and personnel members of AABC and CAABC, or NEBB.

- .2 Company and personnel AABC or NEBB certified.
- .3 Subject to approval.
- .3 Fire Stopping and Smoke Seals: Company member of FCIA.

PART 2 PRODUCTS

2.1 COMMON PRODUCT REQUIREMENTS

- .1 The precise type, quantity and location of products furnished under this Section depends, in part, on routing and installation choices made by Contractor. Provide products:
 - .1 Rated to handle the extremes of temperature, pressure, abrasion, and corrosion to which they will be subjected.
 - .2 With materials suitable for the fluid type and conditions to which they will be exposed.
 - .3 Appropriately sized as required.
 - .4 As indicated.
 - .5 To ASME-B31.9.
 - .6 To CSA-B214.
- .2 Piping Components and Fittings
 - .1 Materials: Match pipe unless otherwise indicated or required for system performance.
 - .2 Size: Match pipe size unless otherwise indicated or required for system performance including control.
 - .3 Type: Match type consistent with Work where not indicated.
 - .4 Joints: Use flanges for larger than NPS-2 unless otherwise indicated.

2.2 PIPES

- .1 Provide as required.
- .2 Types
 - .1 CO-T - Copper Tube
 - .1 To ASTM-B88.
 - .2 Type
 - .1 CO-T-K - Type K (Metric Type A)
 - .2 CO-T-L - Type L (Metric Type B)
 - .3 Weight
 - .1 CO-T-xH - Hard: Use unless otherwise required.
 - .2 CO-T-xS - Soft
 - .2 CS-P - Carbon Steel Pipe
 - .1 To ASTM-A53.
 - .2 Type
 - .1 CS-P-E - Type E: Electric-Resistance Welded, Grade B
 - .2 CS-P-S - Type S: Seamless, Grade B
 - .3 Weight
 - .1 CS-P-x40 - Schedule 40
 - .2 CS-P-x80 - Schedule 80
 - .3 SI-H - Silicone Hose
 - .1 Manufacturers
 - .1 Nexgen Hose Inc., Silicone Tubing, Class 791 Nexsil FDA
 - .2 Type: Minimum of:
 - .1 Manufacturers as listed above.
 - .2 As recommended by combustion equipment manufacturer.
 - .4 SS-P - Stainless Steel Pipe
 - .1 To ASTM-A312.
 - .2 Weight
 - .1 SS-P-10 - Schedule 10
 - .5 Drainage Waste Vent
 - .1 Plumbing
 - .1 PVC or DWV or as required.

- .2 Other Services
 - .1 As indicated, otherwise as required for service, otherwise match piping requirements.

2.3 FITTINGS

- .1 Provide as required, including unions, flanges, tees, and elbows including long and short radius.
- .2 Steel: Screwed and welded including flanged:
 - .1 Screwed Fittings: Malleable iron, to ASME-B16.3.
 - .2 Flanges and Flanged Fittings
 - .1 Steel: To ASME-B16.5.
 - .3 Buttwelding Fittings: Steel, to ASME-B16.9.
 - .4 Unions: Malleable iron, to ASTM-A47 and ASME-B16.3.
 - .5 Bolts and Nuts: To ASME-B18.2.1.
- .3 Copper: Screwed and soldered including flanged:
 - .1 Cast Copper: To ASME-B16.18.
 - .2 Wrought Copper: To ASME-B16.22.
 - .3 Bolts and Nuts: To ASME-A307.
- .4 Bronze: Screwed and brazed including flanged:
 - .1 Screwed Fittings: Cast bronze, to ASME-B16.15.
 - .2 Flanges and Flanged Fittings: To ASME-B16.24.
- .5 Elbows
 - .1 Select elbows with equal inlet and outlet port diameters unless otherwise indicated.
 - .2 Provide long radius type unless otherwise indicated.
 - .3 Provide short radius type when approved by Engineer.

2.4 ANCHORS, GUIDES, SUPPORTS, AND HANGERS

- .1 Design of piping support depends, in part, on routing and installation choices made by Contractor. Design of piping support is Contractor responsibility.
- .2 Provide as required.
 - .1 Design to ASME-B31.9.
 - .2 Design for easy removal.
- .3 Performance
 - .1 Design pipe supports to withstand seismic events as required. Seismic restraint provisions shall meet or exceed requirements for post-disaster buildings in the respective seismic zone.
 - .2 Prevent pipe noise and vibration from being transferred to supporting structure.
 - .3 Angularity of rod hanger resulting from horizontal movement of piping from cold to hot position not to exceed 4-degrees from vertical.
 - .4 For piping at risk of condensation mount hangers over insulation and vapour barrier to prevent condensation of hanger rods, including chilled piping, domestic water, cooling condensate piping, humid or wet environments.

2.5 FIRE STOPPING AND SMOKE SEALS

- .1 Asbestos-free materials and systems capable of maintaining effective barrier against flame, smoke and gases to ULC-S115.
- .2 Manufacturers: 3M Canada Company, Fire Protection Products
- .3 Materials
 - .1 Fire stopping and smoke seal components: Certified by test laboratory to ULC-S115.
 - .2 In assemblies: Systems tested to ULC-S115.
 - .3 In wet environments, waterproof assemblies, or exterior assemblies including foundations and below grade floors: Waterproof, non-hardening.
 - .4 Penetrations requiring vibration control: Elastomeric seal.

- .5 Damming and backup materials, supports and anchoring devices: To manufacturer's recommendations, and in accordance with tested assembly being installed as acceptable to authorities having jurisdiction.
- .6 Other locations: As required.
- .4 Performance: Rating: 2-hours, unless otherwise required.

2.6 BALL SHUTOFF VALVES

- .1 Provide as required.
- .2 Manufacturers
 - .1 Crane Co., Crane
 - .2 Crane Co., Jenkins
 - .3 Kitz Corporation
- .3 Type
 - .1 Heavy duty design.
 - .2 Full port balls.
 - .3 Solid balls with materials as follows as required:
 - .1 Chrome plated.
 - .2 Stainless steel.
 - .4 Double o-ring.
 - .5 Full sized lever handle.
 - .6 Body materials with materials as follows as required:
 - .1 Brass.
 - .2 Stainless steel.
 - .7 Close-off pressure rated for dead-end service with piping on 1 side of shutoff valve disconnected.

2.7 GLOBE MANUAL BALANCING VALVES

- .1 Provide as indicated.
- .2 Manufacturers
 - .1 Armstrong Fluid Technology, CBV-V/CBV-F Series
 - .2 IMI Hydronic Engineering, STAD/STAF Series
 - .3 Oventrop Corporation, Hydrocontrol R/F Series
- .3 Features
 - .1 Globe style valve body.
 - .2 2 x 6-mm (1/4-in) threaded brass metering ports with check valves and gasketed caps.
 - .3 Handwheel capable of minimum 5 full 360-degree turns, complete with micrometer type indicators.
 - .4 Hidden memory stop to set and lock valve position at balance point.
 - .5 Straight or angled configuration as required.
 - .6 If available in product line:
 - .1 Venturi style measuring port built into valve body if available.
 - .2 Flow smoothing fins downstream of valve seat.
- .4 Materials
 - .1 Valve Body, Stem, Disk: Cast iron for flanged, brass otherwise.
 - .2 Seat: EPDM or Viton as required.
 - .3 Handhweel: Reinforced nylon.
- .5 Options
 - .1 Provide metering port extensions for insulated piping.
- .6 Not Acceptable: Use as a shutoff valve.

2.8 STRAINERS

- .1 Provide as indicated.
- .2 Manufacturers
 - .1 Armstrong International, Inc.
 - .2 ISLIP Flow Controls Inc.

- .3 Spirax-Sarco Limited
- .3 Type
 - .1 NPS-2 and under:
 - .1 "Y" type.
 - .2 Screwed cleanout plug.
 - .2 NPS-2-1/2 to NPS-8:
 - .1 "Y" type.
 - .2 Bolted cleanout plug.
 - .3 Above NPS-8:
 - .1 "T" type.
 - .2 Bolted cleanout plug.
 - .4 Screen: Stainless steel.
 - .5 Materials: As required.
 - .6 Blowout: 19-mm (3/4-in) blow off valve unless otherwise indicated.

2.9 CHECK VALVES

- .1 Provide as indicated.
- .2 Manufacturers
 - .1 Crane Co.
 - .2 ISLIP Flow Controls Inc.
 - .3 Spirax-Sarco Limited
- .3 Type
 - .1 NPS-2 and under:
 - .1 Type: Swing.
 - .2 Body: Y pattern with integral seat at 45-degrees, screw in cap with hex head.
 - .3 Disc: Renewable rotating disc, 2 piece hinge disc construction.
 - .4 Seat: Regrindeable.
 - .2 NPS-2-1/2 and above:
 - .1 Type: As required.
 - .2 Body: Bolted cover, tapped and plugged opening on each side for hinge pin.
 - .3 Disc: Secured to stem, rotating for extended life.
 - .4 Seat: Regrindable, integral with body.
 - .3 Materials: As required.

2.10 RELIEF VALVES

- .1 Provide as required, including the following:
 - .1 Temperature relief valves.
 - .2 Pressure relief valves.
 - .3 Combined temperature and pressure relief valves.
 - .4 Automatic reseating combined temperature and pressure.

2.11 DRAIN VALVES

- .1 Provide as required.
- .2 Manufacturers
 - .1 Crane Co.
 - .2 Conbraco Industries, Inc., Apollo
 - .3 Toyo Valve Co., Ltd.
- .3 Sediment Faucets
 - .1 Provide 13-mm (1/2-in) sediment faucets with hose thread outlets.
 - .2 Materials: Brass unless otherwise required.

2.12 AIR VENTS

- .1 Provide as required.
- .2 Manufacturers
 - .1 Maid-O'-Mist, No. 7 Series
 - .2 Taco, Inc., 409

- .3 Honeywell International Inc., EA122 Series
- .4 Spirax-Sarco Limited, 13WS

2.13 COMBINED AIR VENT AND VACUUM BREAKERS

- .1 Provide as required.
- .2 Manufacturers
 - .1 Armstrong International Inc., TAVB Series
 - .2 Watts Industries (Canada) Inc., FV-4M1

2.14 PRESSURE GAUGES

- .1 Provide as required.
- .2 Manufacturers
 - .1 H.O. Trerice Co.
 - .2 Winters Instruments
- .3 Size
 - .1 Piping system served by gauge not greater than NPS-2: 63-mm (2-1/2-in) diameter dial face.
 - .2 Piping system served by gauge greater than NPS-2: 100-mm (4-in) or 113-mm (4-1/2-in) diameter dial face.
 - .3 Increase dial size by 50-mm (2-in) diameter when located at more than 2.4-m (8-ft) away from viewing area including floor, operating platform.
- .4 Scale
 - .1 Pressure not greater than 6.9-kPa (1-psi): Dual scale, inches of water gauge and ounces/in² gauge.
 - .2 Pressure greater than 6.9-kPa (1-psi): Dual scale, psi gauge and kilopascal gauge.
- .5 Range: Select scale ranges to suit the application, including operating pressures that may be both above and below atmospheric pressure, with readings at approximately mid-point on the dial.
- .6 Materials
 - .1 Case
 - .1 Exterior: Stainless steel.
 - .2 Interior: Painted steel or aluminum.
- .7 Housing
 - .1 Minimum IP65, certified to CSA-C22.2-60529.
- .8 Performance
 - .1 Accuracy: +/-1-% Grade 1A to ASME-B40.100.

2.15 TEMPERATURE GAUGES

- .1 Provide as required.
- .2 Manufacturers
 - .1 H.O. Trerice Co.
 - .2 Winters Instruments
- .3 Size
 - .1 Piping system served by gauge not greater than NPS-2: 50-mm (2-in) dial face.
 - .2 Piping system served by gauge greater than NPS-2: 100-mm (4-in) or 113-mm (4-1/2-in) diameter dial face.
 - .3 Increase dial size by 50-mm (2-in) diameter when located at more than 2.4-m (8-ft) away from viewing area including floor, operating platform.
- .4 Scale: Dual scale, both Fahrenheit and Celsius degrees, direct reading to 1-°C (2-°F).
- .5 Range: Select scale ranges to suit the application, including operating temperatures.
- .6 Materials
 - .1 As required, including compatible with thermowells.
- .7 Housing
 - .1 Minimum IP65, certified to CSA-C22.2-60529.
- .8 Performance

- .1 Accuracy: 1-% to 1-1/2-%

2.16 THERMOWELLS

- .1 Provide as required, including for thermometers and other devices including fluid temperature sensors and switches.
- .2 Provide spare thermowells as indicated.
- .3 Provide device and thermowell as a complete assembly, including wellhead and Greenfield fitting.
- .4 Materials: 316 stainless steel
- .5 Construction: Component machined as a single part.
- .6 Unacceptable: Component welded together from separate parts.

2.17 PIPE INSULATION

- .1 Provide insulation on piping and piping components unless otherwise indicated.
- .2 Provide adhesive, tape, sealants, cement, and mastic as recommended by, and compatible with, insulation and insulation jacket manufacturers.
- .3 Common Performance Requirements
 - .1 Flame-Spread: Maximum 25 tested to ULC-S102.
 - .2 Smoke Developed: Maximum 50 tested to ULC-S102.
- .4 Type EF - Flexible Elastomeric Foam
 - .1 Manufacturers
 - .1 Armacell LLC, AP Armaflex Tube Insulation
 - .2 To ASTM-C534.
- .5 Type MF - Preformed Mineral Fibre
 - .1 Manufacturers
 - .1 Johns Manville, Micro-Lok
 - .2 Manson Insulation, ALLEY-K
 - .3 Owens Corning Canada Inc., FIBERGLAS SSL-II
- .6 Certifications, Listings and Registrations
 - .1 To ASTM-C547.
 - .2 To ASTM-C585.
 - .3 To ASTM-C1136.
 - .4 To NFPA-90A.
 - .5 To NFPA-90B.

2.18 JACKETS

- .1 Provide jackets around insulated piping and piping components unless otherwise indicated.
- .2 Common Performance Requirements
 - .1 Flame-Spread: Maximum 25 tested to ULC-S102.
 - .2 Smoke Developed: Maximum 50 tested to ULC-S102.
- .3 Type AL - Aluminum Jacket
 - .1 Provide as required.
 - .2 To ASTM-B209.
 - .3 Thickness: 0.4-mm (0.016-in)
 - .4 Finish: Corrugated unless otherwise indicated.
 - .5 Joining: Longitudinal and circumferential slip joints with 50-mm (2-in) laps.
 - .6 Fittings: 0.5-mm (0.02-in) thick die shaped fitting covers with factory attached protective liner.
 - .7 Banding and Mechanical Seals: 12-mm (1/2-in) wide; 0.5-mm (0.02-in) thick stainless steel.
- .4 Type CAN - Canvas Jacket
 - .1 Provide as required.
 - .2 ULC listed.
 - .3 Fabric: ASTM-C921, 220-g/m² (6-oz/yd²), plain weave cotton treated with dilute fire retardant lagging adhesive.

- .5 Type PVC - Polyvinyl Chloride Jacket
 - .1 Provide as required.
 - .2 Manufacturers
 - .1 Johns Manville, Ceel-Co
 - .2 Knauf Insulation, Proto
 - .3 Provide preformed, moulded type jacketing as required for a complete vapour barrier jacket.
 - .4 To CGSB-51.53.
 - .5 Colour: White unless otherwise indicated.
 - .6 Moisture Vapour Transmission: To ASTM-E96, 0.02-metric-perm (0.03-USperm).
 - .7 Thickness: 0.5-mm (0.02-in)
 - .8 Fastenings: Solvent weld adhesive, unless other fastening means are accepted by Engineer, including tacks, pressure sensitive colour matching vinyl tape.
- .6 Type SS - Stainless Steel Jacket
 - .1 Provide as required.
 - .2 Materials: 304 stainless steel.
 - .3 Thickness: 0.4-mm (0.016-in)
 - .4 Finish: Corrugated unless otherwise indicated.
 - .5 Joining: Longitudinal and circumferential slip joints with 50-mm (2-in) laps.
 - .6 Fittings: 0.5-mm (0.02-in) thick die shaped or fabricated fitting covers.
 - .7 Banding and Mechanical Seals: 12-mm (1/2-in) wide, 0.5-mm (0.02-in) thick stainless steel.

2.19 BACKING BOARD

- .1 Provide as required.
- .2 Materials
 - .1 Rigid high-density polyethylene minimum 9.5-mm (3/8-in) thick laminated on top of pressure impregnated treated plywood minimum 19-mm (3/4-in) thick with fire-retardant chemicals to CSA-O80.
 - .1 Size polyethylene board to extend 12.7-mm (1/2-in) beyond edges of plywood backing.
- .3 Performance
 - .1 Flame-Spread: Maximum 25 tested to ULC-S102.
- .4 Finish: Painted plywood to match components and equipment. Select paint type to provide protection of plywood from water or moisture contact.
 - .1 Paint plywood in its entirety before attaching to polyethylene or support mechanism.

2.20 FLUID TREATMENT CHEMICALS

- .1 Provide chemicals as required for start-up and flushing activities.
- .2 Provide chemicals as required for control of corrosion, scale, and biological growth including algae.

PART 3 EXECUTION

3.1 EXAMINATION

- .1 Inspect distribution piping for the existence of piping dead legs and sections that cannot be drained down. Notify Engineer of discoveries.
- .2 Determine exact location and routes for piping. Modify routing and/or relocate existing services as required.
- .3 Complete x-ray scans, consultation, and other investigative work as required to verify structural member construction, verify suitable locations, and ensure drilling and coring through structural members will not affect integrity.
- .4 Investigate fire separations and non-fire-resistance rated assemblies in affected areas for existing fire stopping or smoke sealing that is improperly sealed or defective, as well as for penetrations not fire stopped or smoke sealed.

3.2 PREPARATION

- .1 Eliminate piping dead legs and sections that cannot be drained down.
- .2 Flush and clean affected piping systems including new and existing piping and piping components before being put into service.

3.3 COMMON EXECUTION REQUIREMENTS

- .1 Install products including piping joining method:
 - .1 As indicated.
 - .2 To ASME-B31.9.
 - .3 To CSA-B214.
 - .4 Welding
 - .1 To CSA-W59.
 - .2 Filler metals and allied materials to CSA-W48.
 - .3 Prepare galvanized components before welding by scraping off galvanizing prior to welding.
 - .5 Soldering
 - .1 Soldering to ASTM-B828.
 - .2 Solders to ASTM-B32.
 - .3 Fluxes for soldered joints to ASTM-B813.
 - .4 Solders and fluxes to have less than 0.2-% lead content.
 - .6 Brazing
 - .1 In addition to soldering requirements, brazing alloys to AWS-A5.8, BCuP range.
 - .7 Solvent Welding
 - .1 To piping manufacturer's instructions.
- .2 Unless otherwise indicated, provide and install piping and components to meet equipment manufacturer's requirements.
- .3 Install concealed piping to minimize furring space, maximize headroom, and conserve space.
- .4 Install piping components in accessible locations.
- .5 Install to permit separate thermal insulation of each pipe unless otherwise indicated.
- .6 Install to eliminate piping dead legs and sections that cannot be drained down.
- .7 Group piping wherever possible.
- .8 Grade: Slope piping as required to ensure proper drainage.
- .9 Di-electric Connections: Provide for cathodic protection wherever dissimilar piping materials are connected together.
- .10 Ensure piping is not supported from other services, including other piping systems.
- .11 Ensure other services are not supported from piping, including other piping systems and wiring.

3.4 PIPES

- .1 Install as required.
- .2 Completely remove burrs, sharp edges, and other discontinuities from inside and outside surfaces of pipes and fittings prior to joint connection.
- .3 Promptly remove excess flux from inside and outside surfaces of pipes and fittings following soldering or brazing.
- .4 Minimize time between application of flux and completion of soldering or brazing.

3.5 FITTINGS

- .1 Install as required.

3.6 ANCHORS, SUPPORTS, GUIDES AND HANGERS

- .1 Design and provide anchors, supports, guides and hangers as required.
- .2 Fasteners: Wedge, sleeve or epoxy type anchor bolts. Refrain from using self-drilling or power-driven anchor bolts.
- .3 Anchors: Locate concrete anchors for equipment away from edges, stress joints, or existing fractures. Follow manufacturer's instructions on minimum anchor spacing.

- .4 Hangers: Use trapeze type hangers where pipes are grouped together, unless otherwise indicated. Suspend horizontal member by adjustable rods with locking feature for maintaining level and slope. Provide auxiliary steel required to support trapeze between building steel.
- .5 Refrain from hanging pipe from another pipe unless otherwise indicated.
- .6 Adjust support system including hangers to equalize load.

3.7 PENETRATIONS

- .1 Provide sleeves at penetrations and where piping passes through assemblies including walls, floors and ceilings.
- .2 Pack sleeves with resilient packing or fire rated packing and materials as required.
- .3 Flash parts built into or passing through to wet environments, waterproof assemblies, or exterior assemblies including roofs, outside walls.
- .4 Patch holes to match existing surfaces.
- .5 Provide minimum clearances as required between sleeves and uninsulated or insulated piping with minimum of:
 - .1 From Combustibles: As required.
 - .2 Below Grade: 25-mm (1-in)
 - .3 Other Locations: 13-mm (1/2-in)
- .6 Sleeve Materials
 - .1 Exterior Assemblies: Carbon steel schedule 40, primed and painted.
 - .2 Masonry and Concrete Assemblies: Carbon steel schedule 40, primed and painted.
 - .3 Interior Frame Construction Assemblies in Conditioned Spaces: Carbon steel schedule 40.
 - .4 Other Frame Construction Assemblies: Carbon steel schedule 40 primed and painted.
- .7 Extend floor sleeves 38-mm (1-1/2-in) above floor surface.
- .8 Seal floor sleeves with an approved stiff setting caulking compound to serve as a water dam.
- .9 Conceal sleeves at penetrations in finished areas with approved escutcheons.

3.8 FIRE STOPPING AND SMOKE SEALS

- .1 Fire stop and smoke seal at fire-resistance rated assemblies including:
 - .1 Penetrations through masonry, concrete, and frame construction including gypsum board partitions and walls.
 - .2 Penetrations through floor slabs, ceilings and roofs.
 - .3 Openings and sleeves installed for future use.
 - .4 Services, including mechanical and electrical.
 - .5 As indicated.
- .2 Fire stop and smoke seal at non-fire-resistance rated assemblies including:
 - .1 Assemblies not fire-resistance rated but constructed as such.
 - .2 As indicated.
- .3 Install fire stopping and smoke seal material and components in accordance with manufacturer's certified tested system listing.
- .4 Install to allow for movement and thermal expansion of services including piping and ducting.
- .5 Ensure integrity of fire stopping and smoke seals are such that passage of flame, smoke and gases is prevented to unexposed side of assembly. Repair as required.
- .6 Ensure integrity of insulation and vapour barriers. Repair as required.
- .7 Repair holes, gaps, openings and improperly fire stopped and smoke sealed penetrations in affected assemblies.
- .8 Provide tags for each fire stopping and smoke seal. Include relevant information on tags including installer name, company, trade license, installation date, fire stopping and smoke seal assembly number. Mount at locations as approved by Owner or as required by authorities having jurisdiction.

3.9 SHUTOFF VALVES

- .1 Install as required.
- .2 Provide shutoff valves to facilitate isolation and maintenance of serviceable equipment and piping components in addition to indicated locations.
- .3 Install with stems above horizontal position unless otherwise indicated.
- .4 Install isolating shutoff valves at branch take-offs for isolating purposes, unless otherwise specified.
- .5 Install remote operators including chains on shutoff valves NPS-2-1/2 or larger where installed more than 2.4-m (8-ft) above floor.
- .6 Provide caps for shutoff valves that terminate at end of piping. Provide threaded caps complete with chain for shutoff valves NPS-2 and smaller. Provide joint type as indicated for piping on shutoff valves larger than NPS-2.
- .7 Provide numbered brass tags for identification for existing and new shutoff valves in affected areas. Coordinate numbering with existing and new shutoff valve charts. Provide new shutoff valve chart for affected areas, listing new and existing shutoff valves. Provide appropriately sized frames with glass cover for each affected area. Match existing shutoff valve chart frames unless otherwise approved by Owner. Mount shutoff valve charts in frames on walls of affected areas in locations approved by Owner.
- .8 Install with sufficient clearance to allow valve handle to travel through its full swing without contacting any materials and without modification to valve or adjacent materials such as bending valve handle or removing insulation.

3.10 GLOBE MANUAL BALANCING VALVES

- .1 Install as required.
- .2 Install with stems above horizontal position unless otherwise indicated.
- .3 Provide 1 temperature/pressure test gauge kit for every 100 installed valves.
- .4 Provide numbered brass tags for identification for existing and new balancing valves in affected areas. Coordinate numbering with existing and new balancing valve charts. Provide new balancing valve chart for affected areas, listing new and existing balancing valves. Provide appropriately sized frames with glass cover for each affected area. Match existing balancing valve chart frames unless otherwise approved by Owner. Mount balancing valve charts in frames on walls of affected areas in locations approved by Owner.

3.11 STRAINERS

- .1 Install as required.
- .2 Coordinate strainer basket mesh size for multiple strainers within same piping loop to:
 - .1 Protect equipment, components and services as required.
 - .2 Provide downstream strainer with finer mesh size on strainer basket.
- .3 Provide drain piping for blowdown valves.

3.12 CHECK VALVES

- .1 Install as required.

3.13 RELIEF VALVES

- .1 Install as required.
- .2 Set and coordinate temperature and pressure settings with requirements of system and other temperature and pressure control devices including safeties.
- .3 Provide discharge piping to floor drain and terminate in a manner that minimizes the risk of damage or personal injury, including discharging directly above floor drain, funnel or hub drain unless otherwise indicated.

3.14 DRAINS AND DRAIN PIPING

- .1 Provide drain valves and drain connections at low points of piping systems, at equipment, and at section isolating valves, in addition to indicated locations.
- .2 Provide drain valves, drain connections, hose bibs, automatic air vents and vacuum breakers as required to ensure proper operation and ease of servicing.

- .3 Provide threaded drip caps complete with chain on drain valves, drain connections and hose bibs.
- .4 Provide drain piping as indicated.
- .5 Provide drain piping to floor drains and terminate where discharge is visible, including to nearest floor drain, funnel or hub drain unless otherwise indicated.
- .6 Provide drain piping with drain piping routed to avoid tripping, except as follows:
 - .1 Unless otherwise indicated.
 - .2 Drain pipe is a tripping hazard as determined by Owner.
- .7 Provide hoses to connect drain connections to floor drains in cases where drain piping for blowdown valves are not provided.

3.15 AIR VENTS AND VACUUM BREAKERS

- .1 Provide combined air vents and vacuum breakers unless otherwise indicated.
- .2 Provide automatic air vents, vacuum breakers, and combined air vents and vacuum breakers:
 - .1 As indicated.
 - .2 At high points of piping systems in addition to indicated locations.
- .3 Provide isolating valves at each device.
- .4 Provide drain piping.

3.16 PRESSURE GAUGES

- .1 Install in locations that facilitate easy reading including aiming.
- .2 Install in locations to prevent restriction of fluid flow in piping. Increase size of piping as required.
- .3 Mount not higher from the viewing area including floor, operating platform, as follows unless otherwise required:
 - .1 Differential Pressure Gauges: 1.5-m (5-ft)
 - .2 Non-differential Pressure Gauges: 2.4-m (8-ft)
- .4 Provide stem pipes and ancillary components as indicated. Where not indicated, provide stem pipes complete with full port ball type shutoff valve.
- .5 For gauges with multiple connections and shutoff valves, document various shutoff valve modes for specific purposes, including mode title, valve tags, valve positions. Document to be complete with laminated chart.

3.17 TEMPERATURE GAUGES

- .1 Install in locations that facilitate easy reading including aiming.
- .2 Mount not higher than 2.4-m (8-ft) from the viewing area including floor, operating platform.

3.18 THERMOWELLS

- .1 Mount in a threadolet or 13-mm (1/2-in) NPT saddle to allow easy access to thermometers and other devices for repair or replacement.
- .2 Install in locations to prevent restriction of fluid flow of piping. Increase size of piping as required.
- .3 Fill thermowells with a high temperature mineral grease prior to insertion of thermometers and other devices.

3.19 FINISHING

- .1 Paint piping as indicated, and as required where not indicated.

3.20 PIPE INSULATION AND JACKETS

- .1 Replace insulation and jackets on existing piping as indicated.
- .2 Replace damaged insulation and jackets on existing piping affected by Work.
- .3 Provide vapour barrier on piping at risk of condensation.
- .4 Install insulation, and seal seams and joints to prevent corrosion of pipe surface by condensation or precipitation.
- .5 Install to:
 - .1 MICA-NISM.

- .2 TIAC-BPG.
- .6 Maintain continuity and integrity of vapour retarder jacket and finishes to prevent corrosion of pipe surface by condensation or precipitation.
- .7 Insulated Components
 - .1 Provide removable insulation to serviceable components and devices, including nameplates, access hatches and doors, drains, measurement ports, operable components.
 - .1 For smaller removable insulation, use insulation with same or better thermal performance but a type that can be installed with tight fitting friction fits
 - .2 Provide labels on covered components and devices.
- .8 Seams
 - .1 Seal seams using seam sealant acceptable to manufacturer and Engineer.
 - .2 Match seam sealant to jacket.
 - .3 Minimize the number of seams by using full length insulation pieces.
 - .4 Position overlaps to shed water.
 - .5 Locate longitudinal seams at bottom of pipe.
- .9 Supports and Hangers
 - .1 Install supports and hangers outside vapour retarder jacket.
 - .2 Install high compressive strength insulation under pipe supports to prevent compression of insulation.

3.21 PIPE LABELLING

- .1 Provide labels for piping denoting service type, piping service function, and flow direction.
 - .1 Materials: Pressure sensitive vinyl with protective overcoating, waterproof adhesive undercoating, suitable for ambient conditions of continuous 100-%RH and continuous operating temperature of 150-°C (300-°F) with intermittent temperatures of 200-°C (390-°F).
 - .2 Common Requirements
 - .1 To ASME-A13.1.
 - .2 To CGSB-24.3.
 - .3 Text Label: Provide labels with text on full description of service and indication of flow direction and function as applicable, including supply, return, bypass, discharge, relief.
 - .1 Text Description: As required by Owner, including as indicated or match existing, otherwise to indicated requirements and referenced documents.
 - .2 Text Font Type: As required by Owner, otherwise match existing, otherwise to indicated requirements and referenced documents.
 - .3 Text Font Size
 - .1 Minimum 25-mm (1-in) high for services 50-mm (2-in) diameter and smaller based on finished diameter including insulation and jacket.
 - .2 Minimum 75-mm (3-in) high for services 300-mm (6-in) diameter and larger based on finished diameter including insulation and jacket.
 - .3 Minimum 50-mm (2-in) high for other finished services.
 - .4 Increase letter size by 25-mm (1-in) high for services located at more than 2.4-m (8-ft) above floor.
 - .4 Text Colour: As indicated, otherwise as required by Owner, otherwise match existing, otherwise to indicated requirements and referenced documents.
 - .5 Text Label Size
 - .1 Borders: Minimum 25-mm (1-in) border widths around and in addition to text.
 - .2 Width: Minimum 300-mm (12-in) overall width.
 - .6 Background Colour
 - .1 As required by Owner, including as indicated or match existing, otherwise to ASME-A13.1 for label colour scheme and NEMA-Z535.1 for colours.
 - .2 Colour may vary for each service.
 - .4 Flow Direction Label: Provide labels with arrows to indicate flow direction.

- .1 Arrow Direction
 - .1 Provide arrows for normal flow direction of operating service.
 - .2 Provide additional arrows for services intended to normally have flow in both directions including flow reversal.
- .2 Size
 - .1 Width: Minimum 50-mm (2-in) width.
 - .2 Height: To accommodate full circumference of finished service.
- .3 Colour: Arrow colour to match text colour. Background colour to be opposite of text colour, or clear if approved by Engineer.
- .5 Band Label: Provide coloured bands to indicate specific service type group and function.
 - .1 Arrangement: As indicated, otherwise as required by Owner, otherwise to ISO-14726.
 - .2 Size
 - .1 Width: Minimum 90-mm (3-1/2-in) width, including for main colour and additional colour.
 - .2 Height: To accommodate full circumference of finished service.
 - .3 Colours
 - .1 As required by Owner, including as indicated or match existing, otherwise to ISO-14726 for label colour scheme and colours.
 - .2 Colour may vary for each service. Multiple colour labels may be required.
- .6 Locations
 - .1 To facilitate easy reading.
 - .2 To indicated requirements and referenced documents.
- .7 Intervals
 - .1 As follows, or at each change of flow direction, or as required if approved by Engineer.
 - .2 Every 3-m (10-ft) of length for services with 25-mm (1-in) high and shorter text.
 - .3 Every 6-m (20-ft) of length for services with 25-mm (3-in) high and taller text.
 - .4 Every 4.5-m (15-ft) of length for other services.
- .2 Ceiling Labelling
 - .1 Provide coloured labels on ceiling surfaces to indicate equipment and components including the following. Colours indicated are indicative of requirements and Owner may change for each type of equipment or component.
 - .2 Provide labels as acceptable to Owner, including label type, material, size and colour. Owner may require lamacoids, adhesive labels with text, adhesive labels with no text.
 - .3 Mark each label as acceptable to Owner, including equipment label, type, power circuit.

3.22 FIELD QUALITY CONTROL

- .1 Concealment Documentation: Photograph piping work at each stage of concealment including:
 - .1 Painting.
 - .2 Insulating.
 - .3 Installation of jacket.
 - .4 Wall finishing.
 - .5 Other obstructions or concealment.
- .2 Testing Documentation: Photograph piping system and service fluid conditions at each stage of testing including:
 - .1 Flushing.
 - .2 Cleaning.
 - .3 Leak testing.
 - .4 Pressure testing.
 - .5 Other quality control activities.
- .3 Leak Testing

- .1 Leak test each closed system while under test pressure with both a soap solution and an electronic leak detector.
- .4 Pressure Testing: Hydrostatically pressure test each closed system for a minimum of 4-hours or as required. Pressure test to a holding pressure of the minimum of:
 - .1 As required.
 - .2 1.5-times the maximum potential operating pressure.
 - .3 1,034-kPa gauge (150-psi gauge).
 - .4 Maximum component pressure ratings.

3.23 START-UP

- .1 Fill new or existing piping loops affected by Work with appropriate fluids.
- .2 Complete testing and flushing activities.
- .3 Replace filters and strainers on equipment and systems during construction as required and immediately before equipment start-up.
- .4 Replace existing and new filters and strainers on equipment and systems immediately after substantial performance.
- .5 Promptly following filling or addition of any fluid to affected piping loops, provide quantities of fluid treatment chemicals necessary to restore chemical concentrations to levels recommended by fluid treatment service provider.
- .6 Execute equipment start-up procedures as required.

3.24 FLUSHING

- .1 Flush and clean affected piping systems including new and existing piping and piping components before being put into service.
- .2 Flush with appropriate chemicals and fluid temperature as required.
- .3 Flush piping with water flowing at velocity of minimum 1.8-m/sec (6-ft/sec) or as required for period of 2-hours or longer as required to remove dirt, scale, and cuttings from entire length of piping.
- .4 For components at risk of damage due to flushing activities, temporarily replace such components with appropriate fittings for duration of flushing. Return required components to their proper places at the conclusion of flushing activities.
- .5 Disposal of cleaning solutions/chemicals to be approved by authorities having jurisdiction.
- .6 Manufacturers Assistance: Flushing to be approved and completed under supervision of Owner's fluid treatment service company(s).

3.25 ADJUSTING

- .1 Supports and Hangers
 - .1 Vertical under normal operating conditions.
 - .2 Equalize loads.
- .2 Make-up Water and Expansion Tanks
 - .1 Set and coordinate pressure settings with requirements of system and other pressure control devices including make-up water and expansion tanks.
 - .2 Make adjustments under the following combinations of conditions:
 - .1 Flow rate or withdrawal is at maximum, 25-% of maximum, no flow rate.
 - .2 Pressure is at maximum and minimum.
 - .3 Allow for 4 additional site visits after start-up and during Warranty Period for adjustments to pressure settings during system operation and shutdown to improve system performance under various conditions including peak and seasonal loads.

3.26 MAINTENANCE

- .1 Include bi-monthly visit by Owner's fluid treatment service company(s) for first 6-months operation, to check operation and to conduct tests of pertinent fluid treatment systems and submit written report on same.

END OF SECTION 23 05 15

SECTION 23 05 93 BALANCING

PART 1 GENERAL

1.1 SECTION INCLUDES

- .1 Balancing including measurements, testing, adjusting, verification of existing.

1.2 REFERENCED DOCUMENTS

- .1 AABC-TBP: AABC Test and Balance Procedures.
- .2 AABC-TSB: AABC National Standards for Total System Balance, 2002.
- .3 ASHRAE-111: ASHRAE-111-2008 Practices for Measurement, Testing, Adjusting, and Balancing of Building Heating, Ventilating, Air-Conditioning, and Refrigeration Systems.
- .4 NEBB-TABES: NEBB Procedural Standards for Testing, Adjusting, Balancing of Environmental Systems, 2015 (8th Edition).

1.3 DEFINITIONS

- .1 "TAB": Used to describe the process, methods, and requirements of testing, adjusting, and balancing for applicable systems.

1.4 INTENT

- .1 Perform TAB such that indicated systems, equipment and components perform as required.
- .2 Perform TAB on new equipment, and affected systems.
- .3 Perform TAB on the following existing systems and equipment:
 - .1 All air handlers and associated systems including fans, main and branch ductwork, supply terminal boxes, air measurement stations, controls, and all grilles, diffusers, and registers.
 - .2 All exhaust systems including fans, main and branch ductwork, , air measurement stations, controls, and exhaust grilles.
 - .3 Heating plant including pumps, and boilers.
 - .4 Heating distribution system including pumps, piping, heat exchangers, air handler heating coils, and terminal units including perimeter heating, fan coils, forced flow heaters.
 - .5 Air terminal reheat distribution systems pumps, piping, and reheat coils.
 - .6 Calibration of control devices, and determination of control operating setpoints.

1.5 SUBMITTALS FOR ACTION

- .1 TAB Plan
 - .1 Methodology and procedures for performing TAB.
 - .2 Highlighted specific procedures different from referenced documents and other specification sections.
 - .3 Test equipment list with test equipment specifications.

1.6 SUBMITTALS FOR INFORMATION

- .1 Certificates
 - .1 Letter certifying TAB has been completed in accordance with Contract Documents and commissioning requirements.
- .2 Balancing Reports
 - .1 Balancing Reports compliant with AABC-TBP and AABC-TSB, and NEBB-TABES recommendations.
 - .2 Provide system schematic diagram with recorded measurements and requirements. Include time of measurements.
 - .3 Indicate pressure drops across components, including intake and exhaust locations including louvers and grilles.
 - .4 Indicate air conditions for outdoors as well as throughout system at different measurement times.
 - .5 Provide calibration certificates for test equipment used.
- .3 Marked Up Drawings

- .1 Marked up drawing indicating extent of differences between Drawings, building drawings and actual as-built conditions.
- .4 Qualification Statements
 - .1 TAB: Proof of certifications for company and personnel.

1.7 QUALITY ASSURANCE

- .1 Qualifications
 - .1 Company and personnel members of AABC and CAABC, or NEBB.
 - .2 Company and personnel AABC or NEBB certified.
 - .3 Subject to approval.

1.8 ADMINISTRATIVE REQUIREMENTS

- .1 Coordination: Coordinate TAB activities with commissioning requirements.
- .2 Pre-TAB Review
- .3 TAB Plan Review Meeting
 - .1 Schedule and conduct TAB plan review meeting review meeting as required.
 - .2 Review Contract Documents, and confirm in writing adequacy of provisions for TAB.
 - .3 Review specific procedures different from referenced documents and other specification sections.
 - .4 Provide written detailed justification for choice of TAB methodology and procedures when requested by Engineer or Commissioning Authority.
 - .5 Revise and resubmit TAB plan as required to satisfaction of Engineer and Commissioning Authority.
- .4 Phase In Coordination Meeting
 - .1 Coordinate and hold a phase in meeting with Owner to discuss and plan installation plan in coordination with other Work, including controls.

PART 2 PRODUCTS

2.1 TEST INSTRUMENTS

- .1 Accuracy Tolerances: Provide test instruments with scale ranges, accuracies, and resolutions to NEBB-TABES minimum requirements unless otherwise specified.
- .2 Calibrate instruments within 6 months of TAB.

PART 3 EXECUTION

3.1 PRE TAB INSPECTION

- .1 Prior to initiating TAB, complete thorough evaluation of systems, equipment, services and components.
 - .1 Add access hatches as required to access components, including where access hatches are missing or inadequate.
 - .2 Confirm if available documentation has correctly and accurately identified distribution system equipment and components.
 - .3 Confirm if balancing devices and components affecting balancing and distribution systems isolation are present.
 - .4 Inspect condition of balancing devices and components to discover improperly installed, missing, defective or failed components including:
 - .1 Control dampers, manual dampers, draft dampers, fire dampers, balancing dampers.
 - .2 Control valves, shutoff valves, check valves, balancing valves.
 - .5 Confirm if test ports and locations are present and adequate.
 - .6 Confirm clearances and maintenance access to equipment and components are adequate.
 - .7 Confirm physical access to concealed equipment and components are present and adequate.
 - .8 Investigate and review possible system installation deficiencies, including openings, connections.

- .2 Document settings for fan powered box fan speed controller settings/position.
- .3 Provide written report including photographs and descriptions of existing deficiencies and conditions impacting the Work.

3.2 PREPARATION

- .1 Review existing balancing reports, equipment data, and building drawings.
- .2 Prior to starting TAB, confirm:
 - .1 Equipment and systems have been properly started up.
 - .2 Equipment and systems have been verified for proper, normal and safe operation of mechanical and associated electrical and control systems.
 - .3 Required commissioning forms and activities have been fully completed.
- .3 Review and document status of related and potentially related components and systems within or near the vicinity of affected systems and zones that may impact measurements and results of TAB, including open or closed doors, operational ventilation systems, neighbour zone conditions, outdoor ambient conditions.

3.3 COMMON EXECUTION REQUIREMENTS

- .1 Perform TAB to:
 - .1 As indicated.
 - .2 ASHRAE-111.
 - .3 AABC-TSB and AABC-TBP, or NEBB-TABES.
 - .4 Equipment and component manufacturers recommendations.
- .2 Balance flows:
 - .1 As indicated.
 - .2 Where flows are not indicated:
 - .1 Balance equal sized terminals or equipment with equal flows.
 - .2 Proportion flows between unequal sized terminals or equipment proportional to approximate or estimated capacity.
 - .3 Adjust flows as required to minimize overall noise.
 - .3 Balance existing systems to the most recent document available from the following:
 - .1 Balanced flows from most recent Owner accepted balancing report.
 - .2 Design flows from supplemental project and renovation drawings.
 - .3 Design flows from building drawings.
- .3 Balance to optimize system, including as follows.
 - .1 Open existing balancing components and devices to reduce required head before balancing.
 - .2 Rebalance balancing components and devices to reduce required head, including at energy sinks and sources and loads, throughout distribution systems.
- .4 Determine branch and main duct airflows by using multiple Pitot tube traverse method.
- .5 Determine grill, register, and diffuser flows by using a flow measuring hood, calibrated using Pitot tube traverse.

3.4 VENTILATION EQUIPMENT

- .1 Set equipment to minimum outdoor air, and maximum airflow. Measure and record the following:
 - .1 Inlet and outlet total pressure and static pressure.
 - .2 Total pressure and static pressure before and after supply fan.
 - .3 Total pressure and static pressure before and after return fan.
 - .4 Total pressure and static pressure before and after each coil.
 - .5 Total pressure and static pressure before and after filters.
 - .6 Total pressure and static pressure before and after outdoor air damper, and relief/exhaust air damper.
 - .7 Total pressure and static pressure in mixed air plenum.
 - .8 Supply fan RPM, amperage, and power.
 - .9 Return/exhaust fan RPM, amperage, and power.

- .2 Set air handler to 100% outdoor air, and maximum airflow. Measure and record the following:
 - .1 Inlet and outlet total pressure and static pressure.
 - .2 Total pressure and static pressure before and after supply fan.
 - .3 Total pressure and static pressure before and after return fan.
 - .4 Total pressure and static pressure before and after each coil.
 - .5 Total pressure and static pressure before and after filters.
 - .6 Total pressure and static pressure before and after outdoor air damper, and relief/exhaust air damper.
 - .7 Total pressure and static pressure in mixed air plenum.
 - .8 Supply fan RPM, motor current, motor power factor, and motor power.
 - .9 Return/exhaust fan RPM, motor current, motor power factor, and motor power.

3.5 VENTILATION EQUIPMENT - GENERAL

- .1 After air distribution supply system has been balanced, balance ventilation equipment to maximum air flow requirements.
- .2 Adjust fan drives including belts and pulleys as required to balance air flows to values as indicated.
- .3 Record duct static pressure setpoint and fan speeds at the following:
 - .1 Ventilation equipment inlet and outlet.
 - .2 Fans.
 - .3 At each major component within ventilation equipment.

3.6 VENTILATION EQUIPMENT - VARIABLE FLOW

- .1 Variable flow systems include variable air volume and adjustable systems.
- .2 Adjust fan pulleys to obtain 95-% variable drive speed at peak condition, including variable frequency drives and vanes.
- .3 When diversity factor is not provided, determine and record diversity factor.
- .4 Test system at peak airflow, by selectively setting terminal boxes to minimum or reduced airflow.
 - .1 Report on simulated airflow setpoints, static pressure readings, and terminal box damper positions.

3.7 BRANCH BALANCING DEVICES - VARIABLE FLOW

- .1 After balancing downstream of the terminal boxes, set all branch dampers to be 100% open.
- .2 Set air terminal airflow setpoints to a fixed percentage of maximum airflow, where the percentage represents the diversity factor for the system.
- .3 Adjust static pressure setpoint until the most open terminal box damper position is equal to 95% open.
- .4 Leave the balancing damper for the duct branch serving the most open terminal box at 100% open.
- .5 Adjust each branch balancing damper until the maximum open damper position of all the terminal boxes served by the duct branch equals 95%.

3.8 AIR TERMINAL BOXES - GENERAL

- .1 Coordinate with other trades, including controls and building automation system, to calibrate box minimum and maximum flow settings.
 - .1 Verify a minimum of 100-% of each box by Pitot Tube Traverse to NEBB-TABES.
 - .2 Verify existing flow measuring device calibration by comparing Pitot Tube Traverse volume measurements and measured pressure drops across existing flow measuring device to manufacturer's performance curves.

3.9 DIFFUSER, GRILLS, AND REGISTERS

- .1 Measure noise levels at maximum airflow, using the Noise Criteria (NC) method.
- .2 Report on areas having a NC measurement of 35 or greater.

3.10 PUMPS - GENERAL

- .1 Balance pumps to design flow.
- .2 Record the following:
 - .1 Pump inlet and outlet pressure.
 - .2 Pump RPM, motor current, motor power factor, and motor power.
 - .3 When diversity factor is not provided, determine and record diversity factor.

3.11 ADJUSTING

- .1 Re-balancing
 - .1 Re-balance system after additional repairs have been implemented.

3.12 CONTROLS COORDINATION

- .1 Coordinate with controls contractors to confirm setpoints, and suitable operating ranges for:
 - .1 Differential and absolute pressure sensors and switches.
 - .2 Current sensors and switches.
 - .3 Flow sensors and switches.
 - .4 Minimum and maximum flow settings on variable speed pumps.
 - .5 Minimum and maximum flow settings on variable speed fans.
 - .6 Return fan speed settings to coordinate with various supply fan speed settings.

3.13 REPORTING

- .1 After settings and adjustments are completed, repeat completing all measurements throughout equipment and systems without making adjustments.
- .2 Document status of related and potentially related components and systems within or near the vicinity of affected systems and zones that may impact measurements and results of TAB, including open or closed doors, operational ventilation systems, neighbour zone conditions, outdoor ambient conditions.
- .3 Prepare report to NEBB-TABES recommendations.

3.14 VERIFICATION

- .1 Reported results subject to verification.
- .2 Provide personnel to verify up to 20-% of reported results, unless otherwise indicated.
- .3 Repeat TAB as required to satisfaction of Engineer.

3.15 SETTINGS

- .1 After TAB is completed, restore systems, equipment and components back to good working order, including remount drive guards, close access doors, lock devices in set positions, and ensure sensors and automatic controls are reverted back to normal operation.
- .2 Permanently mark settings to allow restoration of original settings.

END OF SECTION 23 05 93

SECTION 23 30 00 DUCTWORK

PART 1 GENERAL

1.1 SECTION INCLUDES

- .1 Ducts, dampers, connectors, liners, diffusers, grilles.

1.2 REFERENCED DOCUMENTS

- .1 AMCA-500-D: ANSI/AMCA-500-D-12 Laboratory Methods of Testing Dampers for Rating.
- .2 AMCA-511: AMCA-511-13 Certified Ratings Program - Product Rating Manual for Air Control Devices.
- .3 ASME-A13.1: ASME-A13.1-2015 Scheme for the Identification of Piping Systems.
- .4 ASTM-A653: ASTM-A653/A653M-08 Standard Specification for Steel Sheet, Zinc Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.
- .5 ASTM-A653: ASTM-A653/A653M-15 Standard Specification for Steel Sheet, Zinc Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.
- .6 ASTM-B209: ASTM-B209-14 Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.
- .7 ASTM-C553: ASTM-C553-15 Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications.
- .8 ASTM-C612: ASTM-C612-14 Standard Specification for Mineral Fiber Block and Board Thermal Insulation.
- .9 ASTM-C921: ASTM-C921-10 (R2015) Standard Practice for Determining the Properties of Jacketing Materials for Thermal Insulation.
- .10 ASTM-C1071: ASTM-C1071-16 Standard Specification for Fibrous Glass Duct Lining Insulation (Thermal and Sound Absorbing Material).
- .11 ASTM-C1136: ASTM-C1136-16 Standard Specification for Flexible, Low Permeance Vapor Retarders for Thermal Insulation.
- .12 ASTM-C1290: ASTM-C1290-16 Standard Specification for Flexible Fibrous Glass Blanket Insulation Used to Externally Insulate HVAC Ducts.
- .13 ISO-14726: ISO-14726-2008 Ships and Marine Technology - Identification Colours for the Content of Piping Systems.
- .14 MICA-NISM: MICA National Commercial and Industrial Insulation Standards Manual, 2016 (8th Edition).
- .15 NEMA-Z535.1: ANSI/NEMA-Z535.1-2006 (R2011) Safety Colors.
- .16 NFPA-90A: NFPA-90A-15 Standard for the Installation of Air-Conditioning and Ventilating Systems.
- .17 NFPA-90B: NFPA-90B-15 Standard for the Installation of Warm Air Heating and Air-Conditioning Systems.
- .18 NFPA-701: NFPA-701-15 Standard Methods of Fire Tests for Flame Propagation of Textiles and Films.
- .19 SMACNA-006: ANSI/SMACNA-006-2005 HVAC Duct Construction Standards - Metal and Flexible.
- .20 TIAC-BPG: TIAC Mechanical Insulation Best Practices Guide.
- .21 ULC-S102: CAN/ULC-S102-10 Surface Burning Characteristics of Building Materials and Assemblies.
- .22 ULC-S109: CAN/ULC-S109-14 Flame Tests of Flame Resistant Fabrics and Films.
- .23 ULC-S115: CAN/ULC-S115-11 (R2016) Standard Method of Fire Tests of Firestop Systems.

1.3 DEFINITIONS

- .1 "Ductwork": This refers to the sheet metal, joints, turning vanes, transitions, flanges, hangers, insulation mounts, and other accessories making up a duct section or sections.

1.4 SUBMITTALS FOR ACTION

- .1 Product Data
 - .1 Manufacturers' product literature, specifications, and datasheets. Include product characteristics, performance criteria, options, and limitations.
 - .2 Control Damper Schedule including a separate line for each damper provided and a column for each of the damper attributes, including: ID, Fail Position, Damper Type, Damper Operator, Duct Size, Damper Size, Mounting, and Actuator Type and Details.
- .2 Shop Drawings
 - .1 Duct Routing
 - .1 Layout and Interference Plans: Isometric sketches indicating clearances, interferences, and relocation of interfering services, components, objects, and structures.
 - .2 Fire Separations: Location of penetrations through fire separations and other assemblies.
 - .3 Duct Drainage: Indicate details of duct slope angles and drainage where applicable.
 - .4 Expansion Compensation: Location of ductwork expansion control measures.
 - .5 Vibration Isolation: Location of vibration isolation connectors.
 - .6 Ports and Gauges: Location of ports and gauges.
 - .2 Mounting: Details of bases, hangers, and supports.
 - .3 Suspension Systems: Indicate the following for all suspended equipment:
 - .1 Location of suspension.
 - .2 Maximum load at each of the suspension points.
 - .3 Size of suspension rods or members.
 - .4 Details of supplementary structural steel framing members.
 - .4 Penetrations
 - .1 Location of penetrations.
 - .2 Support details including lintels.
 - .3 Sleeve details including dimensions, fasteners, and sealing.
 - .5 Fire Stopping and Smoke Seals
 - .1 Locations and types marked on plan drawing.
 - .2 ULC assembly number certification.
 - .3 Required temperature rise and flame rating.
 - .4 Hose stream rating where applicable.
 - .5 Materials of fire stopping and smoke seals, primers, reinforcements, damming materials, reinforcements, and anchorages/fastenings.
 - .6 Assembly and penetration type and required ratings, adjacent materials.
 - .7 Openings size, thickness, dimensions.
 - .8 Proposed installation methods.
 - .9 Summaries of similar types of penetrations, assembly type and construction, service penetrating assembly, adjacent materials, fire stopping and smoke seal type, ratings, other work required.
 - .10 Copies of ULC certifications for proposed systems and designs for specific devices and materials.
 - .11 Image of sample tag.
 - .6 Labels: Scaled drawings indicating label types, dimensions, layout, locations, wording, font, spacing, colours. Specifically identify letter sizes larger than indicated minimum heights.

1.5 SUBMITTALS FOR INFORMATION

- .1 Certificates
 - .1 Letter certifying duct supports are in compliance with required seismic restraint provisions.
 - .2 Letter certifying that materials comply with specified performance characteristics and physical properties.

- .3 Letter certifying duct supports are in compliance are in compliance with Contract Documents.
- .4 Letter from fire stopping and smoke seals installer certifying that fire stopping and smoke seals have been installed in accordance with regulatory requirements and Contract Documents.
- .5 Letter from licensed fire protection company certifying fire suppression and detection services are in compliance with regulatory requirements.
- .2 Manufacturer Information
 - .1 Operating and Maintenance Manuals
 - .2 Installation Instructions
- .3 Qualification Statements
 - .1 Fire Protection: Proof of licenses for company and personnel.

1.6 SUBMITTALS FOR CLOSEOUT

- .1 Certificates
 - .1 Letter from Contractor certifying all required fire dampers have been provided and installed correctly, and fire dampers product data has been provided including maintenance data for periodic testing.

1.7 QUALITY ASSURANCE

- .1 Qualifications
 - .1 Ductwork: Company member of SMACNA and OSMCA.
 - .2 Fire Protection: Company and personnel to be licensed sprinkler and fire protection installers.
 - .3 Fire Stopping and Smoke Seals: Company member of FCIA.

PART 2 PRODUCTS

2.1 COMMON PRODUCT REQUIREMENTS

- .1 The precise quantity and location of ductwork depends on routing and installation choices made by Contractor. Provide ductwork:
 - .1 As indicated.
 - .2 Rated to handle the extremes of temperature, pressure, abrasion, and corrosion to which they will be subjected.
 - .3 Constructed from materials suitable for the fluid type and conditions to which they will be exposed.
 - .4 Constructed to pressure classification of the greater of unless otherwise indicated:
 - .1 SMACNA 3-inWC.
 - .2 As indicated.
 - .3 Existing ductwork.
- .2 Duct dimensions indicate clear inside dimensions. Adjust duct sizes to accommodate liners and other obstructions.
- .3 Certification: ULC labelled.
- .4 Performance
 - .1 Noise Tolerances: Provide ductwork free from vibration, rattling or drumming under operating conditions.

2.2 DUCTWORK MATERIALS

- .1 Unpainted Ductwork: Galvanized steel with Z275 (G90) zinc coating to ASTM-A653, unless otherwise indicated.
- .2 Painted Ductwork: Galvanized steel with ZF75 (A25) zinc coating to ASTM-A653, unless otherwise indicated.

2.3 ELBOWS AND TRANSITIONS

- .1 Provide elbows of standard radius design with inner radius equal to width of elbow unless otherwise indicated.
- .2 Provide mitred elbows in areas with restricted free space.

- .3 Type
 - .1 90-degree Radius Elbows: Smooth centre line radius of 1.5-times duct diameter, or 5-piece construction, subject to approval.
 - .2 45-degree Radius Elbows: 3-piece construction.
 - .1 Provide branch connections to mains of eccentric conical configuration.
 - .3 Mitered Elbows: Provide air turning vanes for mitered elbows, from 90-degree square elbows up to 45-degree elbows.
 - .4 Air Turning Vanes: Provide small radius, single wall construction air turning vanes. Provide larger radius or double wall construction as required.
 - .5 Exterior Air Intake: Provide 38-mm (1-1/2-in) drain flange in low point of ductwork.
- .4 Size: Fabricate rectangular duct elbows, transition sections and take-off fittings of metal 1 gauge heavier than duct thickness of adjacent duct.

2.4 JOINTS

- .1 To SMACNA standards.
- .2 Type
 - .1 Longitudinal Joints: Use Pittsburgh Lock joints tightly closed along full length of seam.
 - .2 Transverse Joints: Use class to suit duct size and requirements.
 - .1 Manufacturers
 - .1 Ductmate Canada Ltd. flanged connections.
 - .2 Dynair, Division of Carlisle Canada, Nexus 4 bolt flanged connection system.
 - .3 Elbows: Use Pittsburgh Lock seams, with ends to match transverse joints of duct.

2.5 SEAMS

- .1 Seal joints on ductwork to SMACNA standards.
- .2 Common Performance Requirements
 - .1 Flame Resistance: To fabric requirements of ULC-S109.
 - .2 Flame-Spread: Maximum 25 tested to ULC-S102.
 - .3 Smoke Developed: Maximum 50 tested to ULC-S102.
- .3 Manufacturers
 - .1 3M Canada Company, EC800
 - .2 Foster Products, No. 30-07
 - .3 Carlisle Coatings & Waterproofing Inc., Hardcast, Iron Grip 601
 - .4 Duro-Dyne Canada Inc., S-2 or Transcontinental Equipment "MP"
- .4 Type
 - .1 Exterior Air Intake: Continuously solder or seal joints to prevent dripping of moisture through joints.

2.6 VIBRATION ISOLATION DUCT CONNECTORS

- .1 Provide fire retardant heavy fabric vibration isolation for duct connections to equipment.
- .2 Common Performance Requirements
 - .1 Flame-Spread: Maximum 25 tested to ULC-S102.
 - .2 Smoke Developed: Maximum 50 tested to ULC-S102.
- .3 Manufacturers
 - .1 Ventfabrics, Inc., Fabrics for Flexible Connectors
 - .2 Ventfabrics, Inc., Ventglas
- .4 Size: Minimum 100-mm (4-in) wide total during normal operation of equipment and system.
- .5 Certifications
 - .1 To NFPA-701.

2.7 SUPPORTS AND HANGERS

- .1 Design of ductwork support depends, in part, on routing and installation choices made by Contractor. Design of ductwork support is Contractor responsibility.
- .2 Provide as required.
 - .1 To SMACNA standards.

- .2 Design for easy removal.
- .3 Performance
 - .1 Design ductwork supports to withstand seismic events as required. Seismic restraint provisions shall meet or exceed requirements for post-disaster buildings in the respective seismic zone.
 - .2 Prevent ductwork venting noise and vibration from being transferred to supporting structure.
 - .3 Angularity of rod hanger resulting from horizontal movement of ductwork from cold to hot position not to exceed 4-degrees from vertical.
- .4 Hangers
 - .1 Provide mild steel rod hangers of 10-mm (3/8-in) dia. minimum size for ducts over 760-mm (30-in) in width. Provide 38-mm by 38-mm by 3-mm (1-1/2-in by 1-1/2-in by 1/8-in) steel angle across bottom of duct, attached to steel rods.
 - .2 Provide strap hangers of 3-mm by 25-mm (1/8-in by 1-in) mild steel bar stock for ducts up through 760-mm (30-in) width unless otherwise indicated.

2.8 FIRE STOPPING AND SMOKE SEALS

- .1 Asbestos-free materials and systems capable of maintaining effective barrier against flame, smoke and gases to ULC-S115.
- .2 Manufacturers: 3M Canada Company, Fire Protection Products
- .3 Materials
 - .1 Fire stopping and smoke seal components: Certified by test laboratory to ULC-S115.
 - .2 In assemblies: Systems tested to ULC-S115.
 - .3 In wet environments, waterproof assemblies, or exterior assemblies including foundations and below grade floors: Waterproof, non-hardening.
 - .4 Penetrations requiring vibration control: Elastomeric seal.
 - .5 Damming and backup materials, supports and anchoring devices: To manufacturer's recommendations, and in accordance with tested assembly being installed as acceptable to authorities having jurisdiction.
 - .6 Other locations: As required.
- .4 Performance: Rating: 2-hours, unless otherwise required.

2.9 FLEXIBLE DUCT - INSULATED

- .1 Provide as required.
- .2 Manufacturers
 - .1 Flexmaster Co. Ltd., Triple-Lock Thermal
- .3 Features
 - .1 Single ply aluminum construction with mechanical lock spiral joints.
 - .2 Fibreglass Insulation
 - .3 Continuous lengths, not exceeding 3-m (10-ft).
- .4 Options
 - .1 FSK: Foil scrim craft.
 - .2 PE: Polyethelene vapour barrier.
- .5 Performance
 - .1 Thermal Resistance: As indicated.
- .6 Size: Provide continuous lengths, not to exceed 3-m (10-ft).

2.10 DUCT LINERS

- .1 Provide rigid coated duct liners conforming to NFPA-90A and NFPA-90B, of 25-mm (1-in) thickness and 72-kg/m³ (4.5-lb/ft³) density.
- .2 Manufacturers
 - .1 Owens Corning Canada Inc.
 - .2 Johns Manville
 - .3 Manson Insulation Products
 - .4 Fibrex Insulation Inc.

- .3 Fasten duct liners with plate type impaling pins and self-locking washers.
 - .1 Manufacturers
 - .1 Eckels Industries
 - .2 Continental Stud Welding Ltd.
 - .3 Tactoo Series T or weld pins and self locking washers.

2.11 CONTROL DAMPERS - GENERAL

- .1 Provide as required.
- .2 Manufacturers
 - .1 Tamco, Series 1000/1400/1500/9000
- .3 Features
 - .1 Frame: As indicated, otherwise where not indicated select frame type to minimize airflow restriction including:
 - .1 Mount
 - .1 In-Duct: For low velocity systems.
 - .2 Flanged: For high velocity systems or systems with low noise requirements.
 - .3 ERF: Extended rear flange. For non-ducted openings.
 - .4 RDT: Round duct transition kit. For square or rectangular dampers onto round duct.
 - .2 Depth: 200-mm (4-in)
 - .2 Blades: As indicated, otherwise where not indicated:
 - .1 Depth: 300-mm (6-in)
 - .2 Orientation: Horizontal.
 - .3 Action
 - .1 Opposed blade for modulating dampers.
 - .2 Parallel blade for on/off dampers.
 - .3 Leakage
 - .1 Minimum class as indicated. Maximum leakage as indicated. Otherwise to Class 1 where not indicated.
 - .2 Tested to AMCA-500-D.
 - .4 Pressure: Maximum blade design total static pressure to match distribution system. Configure blades and sections as required.
 - .5 Design
 - .1 Frames: Duct mounting flanges on both sides of entire frame.
 - .2 Blade and Frame Seals: Secured in integral slots and mechanically fastened to prevent shrinkage and movement over life of damper.
 - .3 Linkages: Cup-point trunnion screws to prevent linkage slippage.
 - .4 Bearings: Designed to eliminate action between metal-to-metal or metal-to-plastic riding surfaces. Dual bearing system composed of an inner bearing fixed around hexagon blade pivot pin, rotating within an outer bearing inserted in the frame.
- .4 Materials
 - .1 Frames: Extruded 6063-T5 aluminum, minimum 2.03-mm (0.080-in) thick.
 - .2 Blades: Extruded 6063-T5 aluminum.
 - .3 Blade Seals: Extruded EPDM.
 - .4 Frame Seals: Extruded silicone.
 - .5 Linkages: Aluminum with corrosion-resistant zinc-plated steel linkage hardware.
 - .6 Bearings: Celcon inner bearing, polycarbonate outer bearing.
- .5 Actuators: To Section 25 30 00 Building Control Devices.
- .6 Ratings
 - .1 Temperatures: -40-°C (-40-°F) to 100-°C (212-°F)
- .7 Options
 - .1 ELT - Extreme Low Temperature
 - .1 Materials
 - .1 Blade Seals: Extruded silicone.

- .2 Ratings
 - .1 Temperatures: -73-°C (-100-°F) to 100-°C (212-°F)
- .2 HT - High Temperature
 - .1 Materials
 - .1 Linkages: Bronze oilite trunnion bearings.
 - .2 Bearings: Bronze oilite inner bearing, bronze oilite outer bearing.
 - .2 Ratings
 - .1 Temperatures: -40-°C (-40-°F) to 149-°C (300-°F)
- .3 MR - Moisture Resistance
 - .1 Materials
 - .1 Frames: Assembled using stainless steel screws.
 - .2 Control Shafts: Stainless steel.
 - .3 Linkages: Aluminum with stainless steel linkage hardware.
- .4 SWR - Salt Water Resistance
 - .1 Materials
 - .1 Frames: Clear anodized aluminum to minimum thickness of 18-µm (0.7-in/1,000) deep. Assembled using stainless steel screws.
 - .2 Blades: Clear anodized aluminum to minimum thickness of 18-µm (0.7-in/1,000) deep.
 - .3 Control Shafts: Stainless steel.
 - .4 Linkages: Aluminum with stainless steel linkage hardware.
- .5 TBF - Thermally Broken Frame
 - .1 Features
 - .1 Frame: Internally insulated and thermally broken with thermal cuts, to achieve assembly insulating factor of 0.4-m²·°C/W RSI-value (2.29-hr·ft²·°F/(BTU·in) R-value when combined with TIB option.
 - .2 Materials
 - .1 Frame: Internally insulated with polyurethane resin.
 - .3 Performance
 - .1 Tested to AMCA-500-D.
- .6 TIB - Thermally Insulated Blades
 - .1 Features
 - .1 Blades: Internally insulated and thermally broken, with complete blade insulating factor of 1.16-m²·°C/W RSI-value (6.6-hr·ft²·°F/(BTU·in) R-value.
 - .2 Materials
 - .1 Blades: Internally insulated with expanded polyurethane foam .
 - .3 Performance
 - .1 Tested to AMCA-500-D.
- .8 Certifications, Listings and Registrations
 - .1 To AMCA-511.

2.12 BALANCING DAMPERS

- .1 Provide as required, including at supply terminations including diffusers and grilles.
- .2 Constant Volume Systems
 - .1 Provide balancing dampers at each branch duct and where necessary for proper balancing of system.
- .3 Variable Air Volume Systems
 - .1 Provide balancing dampers at each main branch duct and where necessary for proper balancing of system.

2.13 FIRE DAMPERS

- .1 Provide as required, including provide fire dampers in ductwork passing through fire separations.
- .2 To NFPA-90A, ULC labelled.

- .3 Materials: Provide fire dampers and frames constructed of same materials as duct in which they are installed.
- .4 Type
 - .1 Hinged, fusible link type with channel frames, blades and housing.
 - .2 Type A: For rectangular ducts 250-mm (10-in) or greater.
 - .3 Type B: For rectangular ducts less than 250-mm (10-in). Ensure damper blades are outside of air stream when in open position.
 - .4 Type C: For round ductwork.

2.14 ACCESS HATCHES

- .1 Provide access hatches:
 - .1 At fire dampers, automatic dampers, duct balancing dampers, coils.
 - .2 At equipment and components requiring maintenance, inspections and for convenience purposes.
 - .3 In fixed surfaces including walls, ceilings.
 - .4 At other locations as required.
- .2 Type: Quick opening hardware. Lockable.
- .3 Fasteners
 - .1 General: Provide countersunk holes where fasteners are not concealed.
 - .2 Size: Square with minimum free opening 0.37-m² (4-ft²). Other shapes to be approved by Owner.
- .4 Finish: To match fixed surfaces.

2.15 DUCT INSULATION

- .1 Provide insulation on all ductwork, unless otherwise indicated.
- .2 Provide adhesive, tape, sealants, cement, and mastic as recommended by, and compatible with, insulation and insulation jacket manufacturers.
- .3 Common Performance Requirements
 - .1 Flame-Spread: Maximum 25 tested to ULC-S102.
 - .2 Smoke Developed: Maximum 50 tested to ULC-S102.
- .4 Type MF-B - Mineral Fibre Board
 - .1 Manufacturers
 - .1 Johns Manville, 800 Series Spin-Glas
 - .2 Manson Insulation, AK Board
 - .3 Owens Corning Canada LP, 700 Series FIBERGLAS
 - .2 Features
 - .1 Thickness: As indicated.
 - .2 Density: 3-lb/ft³ (48 kg/m³)
 - .3 Options
 - .1 ASJ: White all service jacket.
 - .2 FSK: Foil scrim kraft facing.
 - .4 Certifications, Listings and Registrations
 - .1 To ASTM-C612.
 - .2 To ASTM-C1136.
 - .3 To NFPA-90A.
 - .4 To NFPA-90B.
- .5 Type MF-L - Mineral Fibre Liner Board
 - .1 Manufacturers
 - .1 Johns Manville, Linacoustic R-300
 - .2 Manson Insulation, Akousti-Liner R
 - .3 Owens Corning Canada LP, QuietR
 - .2 Features
 - .1 Thickness: As indicated.
 - .2 Density: 3-lb/ft³ (48 kg/m³)
 - .3 Performance

- .1 Sound Absorption Coefficient (NRC): Minimum 0.9.
- .4 Certifications, Listings and Registrations
 - .1 To ASTM-C1071.
 - .2 To NFPA-90A.
 - .3 To NFPA-90B.
- .6 Type MF-W - Mineral Fibre Wrap
 - .1 Manufacturers
 - .1 Johns Manville, Microlite EQ
 - .2 Manson Insulation, Alley Wrap
 - .3 Owens Corning Canada LP, SOFTR
 - .2 Features
 - .1 Thickness: As indicated.
 - .2 Density: 1.5-lb/ft³ (24 kg/m³)
 - .3 Options
 - .1 FSK: Foil scrim kraft facing.
 - .2 PSK: Metalized polypropylene scrim kraft facing.
 - .4 Certifications, Listings and Registrations
 - .1 To ASTM-C553.
 - .2 To ASTM-C1136.
 - .3 To ASTM-C1290.
 - .4 To NFPA-90A.
 - .5 To NFPA-90B.

2.16 JACKETS

- .1 Provide jackets around insulated ductwork unless otherwise indicated.
- .2 Common Performance Requirements
 - .1 Flame-Spread: Maximum 25 tested to ULC-S102.
 - .2 Smoke Developed: Maximum 50 tested to ULC-S102.
- .3 Type AL - Aluminum Jacket
 - .1 Provide as required.
 - .2 To ASTM-B209.
 - .3 Thickness: 0.4-mm (0.016-in)
 - .4 Finish: Smooth unless otherwise indicated.
 - .5 Joining: Longitudinal and circumferential slip joints with 50-mm (2-in) laps.
 - .6 Fittings: 0.5-mm (0.02-in) thick die shaped fitting covers with factory attached protective liner.
 - .7 Metal jacket banding and mechanical seals: 12-mm (1/2-in) wide; 0.5-mm (0.02-in) thick stainless steel.
- .4 Type CAN - Canvas Jacket
 - .1 Provide as required.
 - .2 ULC Listed.
 - .3 Fabric: ASTM-C921, 220-g/m² (6-oz/yd²), plain weave cotton treated with dilute fire retardant lagging adhesive.
- .5 Type COM - Composite Membrane
 - .1 Provide as required.
 - .2 Multi-ply embossed UV-resistant aluminum foil and polymer laminate applied to rubberized asphalt layer complete with a metalized polyester film that is coated with low temperature acrylic adhesive.
 - .3 Manufacturers
 - .1 Polyguard Products, Inc., Alumaguard All Weather

2.17 DIFFUSERS - SUPPLY - SQUARE CONE

- .1 Provide as indicated.
- .2 Manufacturers
 - .1 Price Industries Limited, SCD Series

- .3 Features
 - .1 4 cone.
 - .2 White powder coat finish.
- .4 Materials: Steel.
- .5 Materials: Steel.

2.18 GRILLES - RETURN/EXHAUST - EGGCRATE

- .1 Provide as indicated.
- .2 Manufacturers
 - .1 Price Industries Limited, Series 80
- .3 Features
 - .1 Ducted.
 - .2 White powder coat finish.
- .4 Materials: Steel.

PART 3 EXECUTION

3.1 EXAMINATION

- .1 Photograph, document and submit descriptions of existing deficiencies in affected systems, equipment, services and surrounding areas prior to commencing Work.
- .2 Complete x-ray scans, consultation, and other investigative work as required to verify structural member construction, verify suitable locations, and ensure drilling and coring through structural members will not affect integrity.
- .3 Investigate fire separations and non-fire-resistance rated assemblies in affected systems for existing fire stopping or smoke sealing that is improperly sealed or defective, as well as for penetrations not fire stopped or smoke sealed.
- .4 Investigate ductwork through fire separations and non-fire-resistance rated assemblies in affected systems for fire dampers that are improperly selected, installed, defective, or missing.

3.2 PREPARATION

- .1 Demolition and Removal
- .2 Clean new services before being put into service.

3.3 COMMON EXECUTION REQUIREMENTS

- .1 To SMACNA-006.
- .2 Provide screens of 13-mm (1/2-in) mesh x 2.7-mm (0.105-in) diameter removable galvanized wire for air intakes, exhausts and open ends of ductwork, unless otherwise indicated or unless insect screen is required.
- .3 Cross-break flat surfaces as required to prevent vibration or buckling.
- .4 Provide necessary reinforcements, bracing, framing and gaskets.
- .5 Provide required offsets and transitions, whether specifically indicated or not, to facilitate duct arrangement and to avoid interference with building structure, piping, equipment and services.
- .6 Install ductwork as close as possible to walls, partitions and overhead structures to attain maximum headroom and clearance.
- .7 Group ductwork wherever possible.
- .8 Install to permit separate thermal insulation of each duct unless otherwise indicated.
- .9 Install air sealing gaskets between flanged joints at duct connections to equipment.
- .10 Install ductwork size transitions such that angle between the transition and straight run does not exceed 15-degrees, unless otherwise indicated.
- .11 In occupied areas, paint interior of ductwork for at least 600-mm (2-ft) behind supply and exhaust grilles with matte black paint so as to render ductwork invisible from occupied space.
- .12 Slope exhaust ductwork up away from register and without seams in bottom of duct for at least 3-m (10-ft) of duct run behind register.

- .13 Slope exterior air intake ducts down at 1:100 to permit moisture induced by air intake to be drained. Install 38-mm (1-1/2-in) drain flange in bottom of duct at low point and run drain line to nearest floor drain unless otherwise indicated.

3.4 VIBRATION ISOLATION DUCT CONNECTORS

- .1 Install as required.

3.5 SUPPORTS AND HANGERS

- .1 Design and provide supports and hangers as required.
 - .1 Include as required steel framing, braces.
- .2 Unless otherwise indicated, install supports and hangers at intervals not over 2.4-m (8-ft) centres for ducts up to 1.5-m (5-ft) in width and at 1.2-m (4-ft) centres for ducts 1.2-m (5-ft) in width and over.
- .3 Install miscellaneous steel angles or channels as required between joists or building steel for structural support of duct where building framing spacing does not coincide with the required hanger spacing.
- .4 Install 1 handle on either side of short dimension of duct to allow easy removal. Install backing washers or plate for added strength. Match materials to prevent galvanic corrosion.
- .5 Bend strap hanger around bottom of duct with a minimum of 38-mm (1-1/2-in) overlap and attach to sides and bottom of duct.
- .6 Adjust support system including hangers to equalize load.

3.6 PENETRATIONS

- .1 Provide sleeves at penetrations and where ductwork passes through assemblies including walls, floors and ceilings.
- .2 Pack sleeves with resilient packing or fire rated packing and materials as required.
- .3 Install sheet metal closure plates on each side of wall to cover sleeve.
- .4 Flash parts built into or passing through to wet environments, waterproof assemblies, or exterior assemblies including roofs, outside walls.
- .5 Patch holes to match existing surfaces.
- .6 Provide minimum clearances as required between sleeves and uninsulated or insulated ductwork with minimum of:
 - .1 Below Grade: 25-mm (1-in)
 - .2 Other Locations: 13-mm (1/2-in)
- .7 Sleeve Materials
 - .1 Exterior Assemblies: 12-gauge galvanized steel, primed and painted.
 - .2 Masonry and Concrete Assemblies: 12-gauge galvanized steel, primed and painted.
 - .3 Interior Frame Construction Assemblies in Conditioned Spaces: 18-gauge galvanized steel.
 - .4 Other Frame Construction Assemblies: 18-gauge galvanized steel primed and painted.
- .8 Seal floor sleeves with an approved stiff setting caulking compound to serve as a water dam.

3.7 FIRE STOPPING AND SMOKE SEALS

- .1 Fire stop and smoke seal at fire-resistance rated assemblies including:
 - .1 Penetrations through masonry, concrete, and frame construction including gypsum board partitions and walls.
 - .2 Edge of floor slabs at curtain wall and pre-cast concrete panels.
 - .3 Top of masonry and gypsum board partitions.
 - .4 Intersection of masonry and gypsum board partitions.
 - .5 Control and sway joints in masonry and gypsum board partitions and walls.
 - .6 Penetrations through floor slabs, ceilings and roofs.
 - .7 Openings and sleeves installed for future use.
 - .8 Services, including mechanical and electrical.
 - .9 As indicated.
- .2 Fire stop and smoke seal at non-fire-resistance rated assemblies including:
 - .1 Assemblies not fire-resistance rated but constructed as such.

- .2 As indicated.
- .3 Install fire stopping and smoke seal material and components in accordance with manufacturer's certified tested system listing.
- .4 Install to allow for movement and thermal expansion of services including piping and ducting.
- .5 Ensure integrity of fire stopping and smoke seals such that passage of flame, smoke and gases is prevented including to unexposed side of assembly of single sided fire stopping and smoke seals. Repair as required.
- .6 Ensure integrity of insulation and vapour barriers. Repair as required.
- .7 Repair holes, gaps, openings and improperly fire stopped and smoke sealed penetrations in affected assemblies.
- .8 Provide tags for each fire stopping and smoke seal. Include relevant information on tags including installer name, company, trade license, installation date, fire stopping and smoke seal ULC assembly number certification. Mount at locations as approved by Owner or as required by authorities having jurisdiction.

3.8 FLEXIBLE DUCT

- .1 Install as required.
- .2 Supports and Hangers
 - .1 In addition to other indicated requirements, install supports and hangers at intervals not over 1.2-m (4-ft) centres.

3.9 DUCT LINERS

- .1 Install as required.

3.10 CONTROL DAMPERS

- .1 Install as required.

3.11 BALANCING DAMPERS

- .1 Install as required.

3.12 FIRE DAMPERS

- .1 Install as required.

3.13 ACCESS HATCHES

- .1 Install as required.

3.14 DUCT INSULATION AND JACKETS

- .1 Provide as indicated.
- .2 Replace insulation and jackets on existing ductwork as indicated.
- .3 Replace damaged insulation and jackets on existing ductwork affected by Work.
- .4 Install insulation, and seal seams and joints to prevent condensation or precipitation.
- .5 Install to:
 - .1 MICA-NISM.
 - .2 TIAC-BPG.
- .6 Provide 25-mm (1-in) thick acoustic insulation as indicated.
- .7 Insulated Components
 - .1 Provide removable insulation to serviceable components and devices, including nameplates, access hatches and doors, drains, measurement ports, operable components.
 - .1 For smaller removable insulation, use insulation with same or better thermal performance but a type that can be installed with tight fitting friction fits
 - .2 Provide labels on covered components and devices.
- .8 Seams
 - .1 Seal seams using seam sealant acceptable to manufacturer and Engineer.
 - .2 Match seam sealant to jacket.
 - .3 Minimize the number of seams by using full length insulation pieces.
 - .4 Position overlaps to shed water.
 - .5 Locate longitudinal seams at the side of the ductwork that is least visible.

- .9 Supports and Hangers
 - .1 Install supports and hangers outside vapour retarder jacket.
 - .2 Install high compressive strength insulation under duct supports to prevent compression of insulation.
- .10 Additional Finishing
 - .1 Type CAN - Canvas Jacket: Paint jackets.

3.15 DUCTWORK LABELLING

- .1 Provide labels for ductwork denoting service type, ductwork service function, and flow direction.
 - .1 Materials: Pressure sensitive vinyl with protective overcoating, waterproof adhesive undercoating, suitable for ambient conditions of continuous 100-%RH and continuous operating temperature of 150-°C (300-°F) with intermittent temperatures of 200-°C (390-°F).
 - .2 Common Requirements
 - .1 To ASME-A13.1.
 - .3 Text Label: Provide labels with text on full description of service and indication of flow direction and function as applicable, including supply, return, bypass, discharge, relief.
 - .1 Text Description: As indicated, otherwise as required by Owner, otherwise to match requirements for piping from indicated requirements and referenced documents.
 - .2 Text Font Size
 - .1 Minimum 25-mm (1-in) high for services 50-mm (2-in) diameter and smaller based on finished diameter including finsulation and jacket.
 - .2 Minimum 75-mm (3-in) high for services 300-mm (6-in) diameter and larger based on finished diameter including finsulation and jacket.
 - .3 Minimum 50-mm (2-in) high for other finished services.
 - .4 Increase letter size by 25-mm (1-in) high for services located at more than 2.4-m (8-ft) above floor.
 - .3 Text Colour: As indicated, otherwise as required by Owner, otherwise match existing, otherwise to match requirements for piping from indicated requirements and referenced documents.
 - .4 Text Label Size
 - .1 Borders: Minimum 25-mm (1-in) border widths around and in addition to text.
 - .2 Width: Minimum 300-mm (12-in) overall width.
 - .5 Background Colour
 - .1 As required by Owner, including as indicated or match existing, otherwise to match requirements for piping from ASME-A13.1 for label colour scheme and NEMA-Z535.1 for colours.
 - .2 Colour may vary for each service.
 - .4 Flow Direction Label: Provide labels with arrows to indicate flow direction.
 - .1 Arrow Direction
 - .1 Provide arrows for normal flow direction of operating service.
 - .2 Provide additional arrows for services intended to normally have flow in both directions including flow reversal.
 - .2 Size
 - .1 Width: Minimum 50-mm (2-in) width.
 - .2 Height: To accommodate full circumference of finished service.
 - .3 Colour: Arrow colour to match text colour. Background colour to be opposite of text colour, or clear if approved by Engineer.
 - .5 Band Label: Provide coloured bands to indicate specific service type group and function.

- .1 Arrangement: As indicated, otherwise as required by Owner, otherwise to match requirements for piping from ISO-14726.
- .2 Size
 - .1 Width: Minimum 90-mm (3-1/2-in) width, including for main colour and additional colour.
 - .2 Height: To accommodate full circumference of finished service.
- .3 Colours
 - .1 As required by Owner, including as indicated or match existing, otherwise to match requirements for piping from ISO-14726 for label colour scheme and colours.
 - .2 Colour may vary for each service. Multiple colour labels may be required.
- .6 Locations
 - .1 To facilitate easy reading.
 - .2 To match requirements for piping from indicated requirements and referenced documents.
- .7 Intervals
 - .1 As follows, or at each change of flow direction, or as required if approved by Engineer.
 - .2 Every 3-m (10-ft) of length for services with 25-mm (1-in) high and shorter text.
 - .3 Every 6-m (20-ft) of length for services with 25-mm (3-in) high and taller text.
 - .4 Every 4.5-m (15-ft) of length for other services.
- .2 Ceiling Labelling
 - .1 Provide coloured labels on ceiling surfaces to indicate equipment and components including the following. Colours indicated are indicative of requirements and Owner may change for each type of equipment or component.
 - .2 Provide labels as acceptable to Owner, including label type, material, size and colour. Owner may require lamacoids, adhesive labels with text, adhesive labels with no text.
 - .3 Mark each label as acceptable to Owner, including equipment label, type, power circuit.

3.16 DIFFUSERS, GRILLES AND REGISTERS

- .1 Install as required.

3.17 FIELD QUALITY CONTROL

- .1 Photograph ductwork at each stage of concealment including:
 - .1 Painting.
 - .2 Insulating.
 - .3 Installation of jacket.
 - .4 Wall finishing.
 - .5 Other obstructions or concealment.
- .2 Test ductwork before ducts are insulated, painted or concealed.
- .3 Immediately correct defects discovered during tests and retest systems as required.
- .4 Inspect and test ductwork for air leakage at joints and connections to equipment, under normal operating conditions. Provide systems leakage tests to SMACNA requirements.

3.18 CLEANING

- .1 Prior to start-up of fans, blow out complete systems of ductwork with high velocity air for not less than 2-hours using where possible using the installed air handling equipment to full capacity and by blanking off duct sections to achieve required velocity.
- .2 Do not install air filters prior to blow out of ductwork systems. Use auxiliary portable blowers for cleaning where installed fan systems are not adequate to blow out complete system free from dust and dirt.
- .3 Clean interior of plenums, coils, and register, grille or diffuser outlet collars with industrial type vacuum cleaner.
- .4 On completion of cleaning process, replace filters before placing systems in final operation.

3.19 BALANCING

- .1 To Section 23 05 93 Balancing.

3.20 ADJUSTING

- .1 Supports and Hangers
 - .1 Vertical under normal operating conditions.
 - .2 Equalize loads.
 - .3 Adjust and modify to provide ductwork free from vibration, rattling or drumming under operating conditions.
- .2 Balancing
 - .1 Allow for 2 additional site visits after receipt of Owner written approval for comfort adjustments.

END OF SECTION 23 30 00

SECTION 25 30 00 BUILDING CONTROL DEVICES

PART 1 GENERAL

1.1 SECTION INCLUDES

- .1 Control devices, end devices, actuators, transmitters, transducers, sensors, probes.

1.2 REFERENCED DOCUMENTS

- .1 ASHRAE-135: ANSI/ASHRAE-135-2012 BACnet - A Data Communication Protocol for Building Automation and Control Networks.
- .2 ASHRAE-G-11: ASHRAE-G-11-2009 Guideline on Field Testing of HVAC Controls Components.
- .3 CSA-C22.2-60529: CAN/CSA-C22.2-60529-16 Degrees of Protection Provided by Enclosures (IP Code).
- .4 CSA-E60730-1: CAN/CSA-E60730-1-15 Automatic Electrical Controls for Household and Similar Use - Part 1: General Requirements.
- .5 EUL-RoHS: European Union Legislation 2002/95/EC Restriction of Hazardous Substances Directive (RoHS).
- .6 NEMA-250: NEMA-250-2014 Enclosures for Electrical Equipment (1000 Volts Maximum).
- .7 UL-2043: UL-2043-2013 Standard for Fire Test for Heat and Visible Smoke Release for Discrete Products and Their Accessories Installed in Air-Handling Spaces.

1.3 DEFINITIONS

- .1 "Affected Systems": Systems, equipment, services and control systems that are not part of Work but whose operation may be impacted by Work.
- .2 "BACnet": A communications protocol adhering to ASHRAE-135.
- .3 "Device": Transmitters, sensors, probes, and any other device or component in whole or in part that either provides a signal as an input to a controller, or accepts a control signal from a controller, whether or not the device or component may itself act as a controller.
- .4 "ZigBee": A wireless communication protocol adhering to ASHRAE-135.

1.4 SUBMITTALS FOR ACTION

- .1 Product Data
 - .1 Manufacturers' product literature, specifications, and datasheets. Include the following information:
 - .1 Product characteristics.
 - .2 Performance criteria.
 - .3 Options.
 - .4 Limitations.
 - .5 Photographs.
 - .6 Supplier information.
 - .2 Performance criteria for end devices includes accuracy, operating environment tolerances, and stability criteria.
 - .3 Detailed bill of material list for each system or application, identifying quantities, part numbers, descriptions, and optional features.
- .2 Shop Drawings
 - .1 Floor plan drawings showing location of system components.
 - .2 System schematics and flow diagrams indicating point location, name, and hardware address.
 - .3 Device list describing location, function, power supplies, signal conditioning.
 - .4 Wiring and ladder logic diagrams detailing required interfaces and hardware interlocks.
 - .5 Wiring and ladder logic diagrams describing important existing undocumented interfaces and hardware interlocks.
 - .6 Interlocks: Schematic and wiring diagrams detailing electrical interlocks and life safety system interfaces.

1.5 SUBMITTALS FOR INFORMATION

- .1 Manufacturer Information
 - .1 Operating and Maintenance Manuals
 - .2 Installation Instructions
- .2 Testing Report: A report detailing the results of testing activities including the following:
 - .1 Dates of testing activities.
 - .2 Names and contact information of testing technician.
 - .3 Point Calibration Results: Include points and devices tested, method for testing, potential variances, observations including point values, measured values, discrepancies, and a description of corrective action taken.
 - .4 Output Testing Results: Include points and devices tested, method for testing, potential variances, observations including point values, measured values, discrepancies, and a description of corrective actions taken.
 - .5 Failure Mode Test Results
 - .6 Software State Test Results
 - .7 Interlocks Test Results
 - .8 Completed Testing Check List

1.6 SUBMITTALS FOR CLOSEOUT

- .1 Tools and Software
 - .1 4 sets of common keys to enclosures.
 - .2 Control device test kits and calibration kits.

1.7 ADMINISTRATIVE REQUIREMENTS

- .1 Testing Plan Review
 - .1 Submit Testing Plan for approval 20-days prior to testing.
 - .2 Revise the Testing Plan as required to the satisfaction of the Engineer.
 - .3 Submit the Testing Report demonstrating results of testing activities.
 - .4 Coordinate testing activities with Commissioning activities.

1.8 WARRANTY

- .1 Special Warranty
 - .1 Update site documentation including paper and electronic versions as required.

PART 2 PRODUCTS

2.1 EXISTING PRODUCTS

- .1 Indicated devices approximately as indicated. Confirm quantities and details by site investigation and review of available documentation.

2.2 COMMON PRODUCT REQUIREMENTS

- .1 Selection and Completeness
 - .1 Select and size devices to be suitable for the application, including compatibility with controllers, power supplies, signal conditioning hardware, wiring and other equipment, ease of maintenance, adjustability, tolerances, signal resolution, inrush currents, and operating environment.
 - .2 Select device scale ranges to suit the application, including operating temperatures, pressure or vacuum, with readings at approximately mid-point on the scale where applicable.
 - .3 Devices including sensors to be complete with transmitters unless otherwise indicated.
- .2 Options
 - .1 Available product options are defined for each device.
 - .2 Provide devices with the specific product options indicated in Contract Documents.
 - .3 Where specific product options are not indicated elsewhere in Contract Documents, including where a product options field is blank or not present, provide all options for that device.

- .1 In cases of inconsistency(s) or conflict(s) between options, provide options of greater quality or that meet more stringent requirements as determined by Engineer.
- .3 Accuracy and Stability: Indicated device accuracies and stability include errors associated with the sensor, including lead wire, and analog to digital conversion, unless otherwise indicated.
- .4 Fire Resistance Ratings: Where device may be located in a return air plenum or air handling space as defined by local building code, device may be mounted without a separate enclosure with all of the following met:
 - .1 Device listed and labelled to UL-2043.
 - .2 Device has a solid complete housing around all parts.
 - .3 No exposed electronics.
 - .4 No exposed wires that are not separately rated to requires of local building code.
- .5 Settings Maintained: Maintain settings and operation on loss power, network, communication to controllers.
- .6 Substitution Limitations
 - .1 Substitutions may be accepted under substitution provisions described in Contract Documents.
 - .2 Substitutions may be limited by various requirements and may require re-design, including:
 - .1 Performance requirements.
 - .2 Physical characteristics, including weight, height, length, width.
 - .3 Aesthetics.
 - .4 Additional and separate components required.
 - .3 Acceptable Substitution Manufacturers
 - .1 As indicated, otherwise where not indicated, to controller manufacturer.

2.3 COMMON PRODUCT OPTIONS

- .1 Where the following options are indicated, provide devices to this Section except requirements are superseded or supplemented by these common product options.
 - .1 AM-CS: Add additional manufacturer to manufacturers listed under device with control system manufacturer.
 - .2 AM-TU: Add additional manufacturer to manufacturers listed under device with terminal unit manufacturer.
 - .3 MM-CS: Match device manufacturer to that of control system manufacturer, instead of manufacturers listed under device.
 - .4 MM-TU: Match device manufacturer to that of terminal unit manufacturer, instead of manufacturers listed under device.

2.4 ACTUATORS - ELECTRONIC

- .1 Provide as required.
- .2 Manufacturers
 - .1 Belimo Automation AG
 - .2 Bray International, Inc.
 - .3 Johnson Controls, Inc.
- .3 Features
 - .1 Motor: Brushless DC motor with overload protection.
 - .2 Stall Protection: Mechanical or electronic stall protection to prevent damage to actuator throughout rotation of actuator.
 - .3 Manual Positioning: Manual position override with handwheel if available in product series or 5-mm (3/16-in) hex key.
 - .4 Adjustable Stop: Accessible, field adjustable mechanical stop to limit travel in either direction.
 - .5 Compatibility: Ensure compatibility to equipment and components, including valves, dampers, and other devices being positioned by actuator.

- .6 Visual Position Indication: Clearly visible position indicator driven directly by actuator shaft.
- .4 Options
 - .1 Control Input
 - .1 3PF: 3 point floating modulating positioning control. 2 digital signals will open or close the actuator accordingly.
 - .2 O/O: On/off positioning control. Open or close position based on a single digital control signal.
 - .3 PC: Phasecut modulating positioning control.
 - .4 PRO: Proportional modulating positioning control.
 - .1 Repeatable positioning based on a 2-VDC to 10-VDC or 4-mA to 20-mA control signal.
 - .2 Resolution/positioning accuracy minimum 80:1.
 - .5 PWM: Pulse width modulating positioning control.
 - .2 Actuator Speed
 - .1 FA: Fast acting. Move full stroke within 10-sec when driven by motor at temperatures above -20-°C (-4-°F), independent of load.
 - .2 QA: Quick acting. Move full stroke within 20-sec when driven by motor at temperatures above -20-°C (-4-°F), independent of load.
 - .3 SA: Standard acting. Move full stroke within 90-sec when driven by motor at temperatures above -20-°C (-4-°F), independent of load.
 - .4 SP-ADJ: Adjustable speed. Field adjustable full stroke travel time.
 - .1 Minimum range: 40-% to 100-%.
 - .3 Position
 - .1 ES: End switches. Quantity 2 built-in SPDT auxiliary switches. 1 switch fixed at no more than 10-° actuator position, 1 switch field adjustable between 10-° and 90-°.
 - .2 FB: Feedback signal. Built-in true position feedback.
 - .4 Failure Positioning
 - .1 FS: Fail safe. Upon loss of line power, integral batteries or capacitors drive actuator to field adjustable fail position between 0-° and 90-°.
 - .1 Move full stroke within 60-sec at temperatures above -20-°C (-4-°F), independent of load.
 - .2 SR: Spring return. Upon loss of line power, an internal spring drives actuator to field adjustable fail position to either full open or full closed.
 - .1 Move full stroke within 60-sec at temperatures above -20-°C (-4-°F), independent of load.
 - .3 SR-QA: Spring return quick acting. Upon loss of line power, an internal spring drives actuator to field adjustable fail position to either full open or full closed.
 - .1 Move full stroke within 20-sec at temperatures above -20-°C (-4-°F), independent of load.
 - .5 Enclosure
 - .1 ENC: Minimum IP54, certified to CSA-C22.2-60529.
 - .2 ENC5: Minimum IP65, certified to CSA-C22.2-60529. Provide HTR with this enclosure.
 - .6 Other
 - .1 HTR: Heater. Line voltage electric heater, sized to prevent condensation on actuator body.
 - .2 QM: Quiet motion. Noise level not more than 46-dB(A) under motor power at minimum speed.
- .5 Performance
 - .1 Torque: Minimum 125-% of recommended torque for application.
 - .2 Angle of Rotation: 95-°

- .6 Ratings: Without HTR option:
 - .1 Temperature: -20-°C to 50-°C (-4-°F to 122-°F).
 - .2 Humidity: 0-%RH to 95-%RH, non-condensing.
- .7 Certifications, Listings and Registrations
 - .1 CSA-E60730-1.

2.5 ELECTRICAL CURRENT SWITCHES

- .1 Provide as indicated.
- .2 Manufacturers
 - .1 Setra Systems, Inc., CSC Series
- .3 Features
 - .1 Split core current switch.
 - .2 Self powered from conductor cable.
 - .3 Field adjustable current trip setpoint.
 - .4 Over/under current sensing switching mode.
 - .5 Normally open status switch.
 - .6 LED indication.
- .4 Options
 - .1 OUT: Output relay module. SPST-NO relay rated at 10-A@260-VAC and 5-A@30-VDC.
- .5 Performance
 - .1 Current: 1.25-A to 135-A
- .6 Ratings
 - .1 Output Relay
 - .2 Ambient Temperature: -15-°C to 60-°C (5-°F to 140-°F)
 - .3 Ambient Humidity: 0-%RH to 95-%RH
- .7 Certifications, Listings and Registrations
 - .1 EUL-RoHS compliant.

2.6 ELECTRIC SWITCHES - CONTROL RELAY

- .1 Provide as required.
- .2 Features
 - .1 Plug-in relays with separate base.
 - .2 Light emitting diode indicator.

2.7 ELECTRIC SWITCHES - POWER CONTACTOR

- .1 Provide as indicated.
- .2 Features
 - .1 Screw terminals.
 - .2 Visible state indicator.
 - .3 Power: 3 phase unless otherwise required.
- .3 Size: Minimum 150-% of circuit rating.

2.8 PRESSURE SWITCHES - AIR - DIFFERENTIAL - HIGH LIMIT

- .1 Provide as required.
- .2 Type
 - .1 Low differential pressure for air or combustion products that do not degrade silicone.
- .3 Manufacturers
 - .1 Cleveland Controls, Inc., AFS-460-DSS
- .4 Features
 - .1 Enclosure: Plated steel
 - .2 Connections: Ferrule and nut compression connections.
 - .3 Settings
 - .1 Manual reset.
 - .2 Field selectable pressure ranges with lead and lag snap switches.
 - .3 Bidirectional and unidirectional.

- .5 Performance
 - .1 Field Adjustable Range Capability: 1.25-inWC to 12.0-inWC.
 - .2 Maximum Pressure: 0.5-psi.
- .6 Ratings
 - .1 Ambient Temperature: 40-°C to 82-°C (-40-°F to 180-°F).
 - .1 Case: 7-°C (20-°F) to 60-°C (140-°F)
 - .2 Element: Maximum 121-°C (250-°F)
- .7 Certifications, Listings and Registrations
 - .1 UL Approved.

2.9 PRESSURE TRANSMITTERS - AIR - DIFFERENTIAL

- .1 Provide as indicated.
- .2 Type
 - .1 Low differential pressure for air or similar non-conducting gases.
- .3 Manufacturers
 - .1 Setra Systems, Inc., 267/267MR Series
- .4 Features
 - .1 Transmitter Enclosure: Hinged.
 - .2 Probes: 6.3-mm (0.25-in) diameter with baffles to prevent velocity pressure errors.
 - .3 Settings
 - .1 Field zeroing.
 - .2 Bidirectional output at zero.
 - .4 Ranges
 - .1 Available ranges for unidirectional of from 0-Pa (0-inWC) to 25-Pa, 63-Pa, 125-Pa, 250-Pa, 623-Pa, 2,490-Pa (0.1-inWC, 0.25-inWC, 0.5-inWC, 1.0-inWC, 2.5-inWC, 10-inWC).
 - .5 Connections
 - .1 Strain reliefs and raceways openings as required.
- .5 Materials
 - .1 Transmitter Enclosure: Polycarbonate, painted finish.
 - .2 Probes: Extruded aluminum.
 - .3 Pressure Fittings: Brass.
- .6 Options
 - .1 Transmitter
 - .1 AC02
 - .1 Accuracy: +/-0.25-% full scale of root sum square for non-linearity, hysteresis, and non-repeatability.
 - .2 Non-Linearity: +/-0.22-% full scale of best fit line method.
 - .2 AC04
 - .1 Accuracy: +/-0.4-% full scale of root sum square for non-linearity, hysteresis, and non-repeatability.
 - .2 Non-Linearity: +/-0.38-% full scale of best fit line method.
 - .3 AC05
 - .1 Accuracy: +/-0.5-% full scale of root sum square for non-linearity, hysteresis, and non-repeatability.
 - .4 AC1
 - .1 Accuracy: +/-1.0-% full scale of root sum square for non-linearity, hysteresis, and non-repeatability.
 - .2 Non-Linearity: +/-0.98-% full scale of best fit line method.
 - .5 FSR - Field Selectable Ranges
 - .1 Selectable to the following of full range: 100-%, 50-%, 25-%.
 - .2 Sensor
 - .1 UNI - Unidirectional
 - .2 BID - Bidirectional

- .3 Display
 - .1 LCD - Liquid Crystal Display: Display of line pressure and differential pressure, minimum 3 digits.
- .7 Performance
 - .1 Hysteresis: +/-0.10-% full scale.
 - .2 Non-Repeatability: +/-0.5-% full scale.
 - .2 Thermal Effects: Maximum thermal error calibrated at nominal 21-°C (70-°F).
 - .1 Compensated Temperature Range: 5-°C to 65-°C (40-°F to 150-°F)
 - .2 Zero/Span Shift: +/-0.06-°C (+/-0.033-°F) full scale.
 - .3 Long Term Stability: 0.1-% full scale.
- .8 Ratings
 - .1 Housing: Minimum IP65, certified to CSA-C22.2-60529.
 - .2 Pressures
 - .1 Line Pressure: Upper limit of 69-kPa (10-psi) or greater.
 - .2 Over Pressure: Upper limit of 69-kPa (10-psi) or greater at maximum range.
 - .3 Temperatures
 - .1 Transmitter: Ambient: -18-°C to 65-°C (0-°F to 150-°F)
 - .2 Sensor: Pressure Media: Wider range than ambient temperature for transmitter.
- .9 Certifications, Listings and Registrations
 - .1 NIST traceable calibration.

2.10 PRESSURE TRANSMITTERS - LIQUID - DIFFERENTIAL

- .1 Provide as indicated.
- .2 Type
 - .1 Dual sensor wet-to-wet differential pressure.
- .3 Manufacturers
 - .1 Setra Systems, Inc., 231 Series
- .4 Features
 - .1 Transmitter Enclosure: Hinged.
 - .2 Settings
 - .1 Field selectable pressure limits and ranges.
 - .1 Maximum line pressures of 50-psi, 100-psi or 250-psi.
 - .2 Differential pressure ranges adjustable to 10-%, 20-%, 50-% or 100-% based on maximum line pressure settings.
 - .2 Field selected sensors response times.
 - .1 Maximum response time ranges 1-sec through to 5-sec.
 - .3 Field selectable signal outputs.
 - .4 Field zeroing.
- .5 Materials
 - .1 Transmitter Enclosure: Die cast aluminum, powder coated finish.
 - .2 Probes: Stainless steel.
- .6 Options
 - .1 Display
 - .1 LCD: Liquid crystal display of line pressure and differential pressure, minimum 3 digits.
 - .2 Probes
 - .1 RP-F: Remote probe with flexible cable.
 - .2 RP-R: Remote flexible probe. Armoured jacket.
 - .1 Materials: Stainless steel.
 - .3 VM3: 3 valve manifold assembly.
 - .1 Features: Multiple valves mounted in a manifold block as follows:
 - .1 Shutoff valve for connection to positive port.
 - .2 Shutoff valve for connection to negative port.
 - .3 Shunt valve between device and shutoff valves for equalizing pressure.

- .2 Materials: Manifold Block: Brass.
- .4 VM5: 5 valve manifold assembly.
 - .1 Features: Multiple valves mounted in a manifold block as follows:
 - .1 Shutoff valve for connection to positive port.
 - .2 Shutoff valve for connection to negative port.
 - .3 Shunt valve between device and shutoff valves for equalizing pressure.
 - .4 Shutoff valve for connection to external gauge or alternate plumbing configuration on positive port side.
 - .5 Shutoff valve for connection to external gauge or alternate plumbing configuration on negative port side.
 - .2 Materials: Manifold Block: Brass.
- .7 Performance
 - .1 Accuracy: Root sum square at constant temperature of non-linearity, hysteresis, and non-repeatability:
 - .1 +/-2.0-% full scale at differential pressure range setting of 100-%.
 - .2 +/-1.0-% full scale at differential pressure range setting of less than 100-%.
 - .2 Thermal Effects: Maximum thermal error calibrated at nominal 21-°C (70-°F).
 - .1 Compensated Temperature Range: 0-°C to 54-°C (32-°F to 130-°F)
 - .2 Sensor Response Time: Maximum 5-sec.
 - .3 Warm-up Shift: Less than 0.12-% full scale.
 - .4 Zero/Span Shift: Differential less than 1.8-°C (2.0-°F) per 50-°C (100-°F).
 - .5 Proof Pressure: 2-times full scale.
- .8 Ratings
 - .1 Housing: Minimum NEMA Type 4 rated to NEMA-250.
 - .2 Pressures
 - .1 Line Pressure: Upper limit of 1.73-MPa (250-psi) or greater.
 - .2 Burst Pressure
 - .1 15-times full scale at 50-psi maximum line pressure setting.
 - .2 10-times full scale at 100-psi maximum line pressure setting.
 - .3 8-times full scale at 250-psi maximum line pressure setting.
 - .3 Temperatures
 - .1 Transmitter: Ambient: -20-°C to 85-°C (-4-°F to 185-°F)
 - .2 Sensor: Pressure Media: Upper limit of 104-°C (220-°F) or greater.
 - .4 Shock: Withstand minimum 200-g.
 - .5 Vibration: Withstand minimum 10-g from 50-Hz to 2,000-Hz.
 - .9 Certifications, Listings and Registrations
 - .1 EUL-RoHS compliant.
 - .2 NIST traceable calibration.

2.11 TEMPERATURE SWITCHES - AIR - DUCT - LOW LIMIT (FREEZESTATS)

- .1 Provide as indicated.
- .2 Manufacturers
 - .1 Honeywell International Inc., L482 Series
- .3 Features
 - .1 Controller
 - .1 Low limit controller with 1 NO SPST snap switch as well as separate 1 SPST NC snap switch.
 - .2 Manual reset.
 - .3 Setpoint scale and adjustment with slotted screw.
 - .2 Sensor: 6.1-m (20-ft) sensing element.
 - .3 Enclosure: Steel with enamel paint.
- .4 Performance
 - .1 Setpoint Range Capability: -9-°C to 113-°C (15-°F to 55-°F)
 - .2 Differential: Non adjustable and additive 2.77-°C (5-°F)

- .5 Ratings
 - .1 Ambient Temperature
 - .1 Case: 7-°C (20-°F) to 60-°C (140-°F)
 - .2 Element: Maximum 121-°C (250-°F)
- .6 Certifications, Listings and Registrations
 - .1 UL Listed.
 - .2 CAS Listed.

2.12 TEMPERATURE TRANSMITTERS - AIR - DUCT

- .1 Provide as indicated.
- .2 Manufacturers
 - .1 Greystone Energy Systems Inc., TE500/511/512 Series
- .3 Features
 - .1 Transmitter Enclosure: Hinged.
 - .2 Protection Circuitry: Reverse voltage protected and output limited.
- .4 Options
 - .1 Sensor
 - .1 Probe or cable length as required including quantity of multiple points where applicable.
 - .2 NTC: NTC thermistor.
 - .1 Accuracy: +/-0.2-°C (-0.4-°F) over range.
 - .3 RTD: Platinum RTD.
 - .1 Accuracy: +/-0.3-°C (+/-0.54-°F) at 0-°C (32-°F).
 - .4 MPC-F: Multi-point probe with flexible cable.
 - .1 Materials: FT6 plenum rated cable.
 - .5 MPP-F: Multi-point flexible probe.
 - .1 Materials: Copper.
 - .6 MPP-R: Multi-point rigid probe.
 - .1 Materials: 304 stainless steel.
 - .7 SPP-R: Single point rigid probe.
 - .1 Materials: 304 stainless steel.
 - .2 Display
 - .1 LCD: Liquid crystal display of temperature, configurable to display in Celsius and Fahrenheit, minimum 3 digits.
 - .3 Transmitter Enclosure
 - .1 ABS1: ABS enclosure. Minimum IP61, certified to CSA-C22.2-60529.
 - .2 ABS5: ABS weatherproof enclosure. Minimum IP65, certified to CSA-C22.2-60529.
 - .3 GS: Galvanized steel enclosure. Minimum IP50, certified to CSA-C22.2-60529.
 - .4 ALU: Cast aluminum weatherproof enclosure. Minimum IP64, certified to CSA-C22.2-60529.
 - .5 Performance
 - .1 Sensor Range Capability: -20-°C to 105-°C (-4-°F to 221-°F)
 - .2 Transmitter Accuracy: +/-0.1-% of span, including linearity.
 - .6 Ratings
 - .1 Ambient Temperature: 0-°C to 70-°C (32-°F to 158-°F), or -40-°C to 85-°C (-40-°F to 185-°F) if required by location.
 - .2 Ambient Humidity: 0-%RH to 95-%RH non-condensing.
 - .7 Certifications, Listings and Registrations
 - .1 EUL-RoHS compliant.

2.13 TEMPERATURE TRANSMITTERS - AIR - ZONE

- .1 Provide as indicated.
- .2 Manufacturers
 - .1 Greystone Energy Systems Inc., SPC/TE500AD/TE500AS/TXRC Series

- .3 Features
 - .1 Protection Circuitry: Reverse voltage protected and output limited.
- .4 Options
 - .1 Sensor
 - .1 NTC: NTC thermistor temperature sensor. Additional to humidity sensor.
 - .1 Accuracy: +/-0.2-°C (-0.4-°F) over range.
 - .2 Sensor Range Capability: 0-°C to 50-°C (32-°F to 122-°F)
 - .2 RTD: Platinum RTD temperature sensor. Additional to humidity sensor.
 - .1 Accuracy: +/-0.3-°C (+/-0.54-°F) at 0-°C (32-°F).
 - .2 DSE: Décor style enclosure.
 - .1 Colour: White.
 - .2 Materials: ABS
 - .3 Ratings: Minimum IP20, certified to CSA-C22.2-60529.
 - .4 Dimensions: 70-mm x 114-mm x 32-mm (2.75-in x 4.5-in x 1.25-in)
 - .5 Ratings
 - .1 Ambient Temperature: 0-°C to 70-°C (32-°F to 158-°F)
 - .2 Ambient Humidity: 0-%RH to 95-%RH non-condensing.
 - .3 MFE: Multi-function enclosure.
 - .1 Colour: White.
 - .2 Materials: ABS
 - .3 Ratings: Minimum IP20, certified to CSA-C22.2-60529.
 - .4 Dimensions: 84-mm x 117-mm x 29-mm (3.3-in x 4.6-in x 1.15-in)
 - .5 Display Options
 - .1 LCD: Liquid crystal display of temperature, configurable to display in Celsius and Fahrenheit, minimum 3 digits.
 - .2 LED-G: LED indicator, green colour.
 - .3 LED-R: LED indicator, red colour.
 - .4 LED-Y: LED indicator, yellow colour.
 - .5 SPA-T: Temperature setpoint adjustment. Front panel mount, slide potentiometer.
 - .6 Other Options
 - .1 ORS: Override switch. Front panel mount, momentary push-button, 2 wire dry contact (NO SPST 50-mA@12-VDC).
 - .2 SSS5: Speed selector switch. Side panel mount, 5 position switch. Typically used for fans. Range: Off, Auto, Low, Medium, High.
 - .3 COMJ: Communications jack. 4-pin header connector to 4-pin terminal block.
 - .7 Ratings
 - .1 Ambient Temperature: 0-°C to 50-°C (32-°F to 122-°F)
 - .2 Ambient Humidity: 0-%RH to 95-%RH non-condensing.
 - .4 SPE: Moisture resistant steel plate enclosure.
 - .1 Materials: 304 stainless steel plate.
 - .2 Ratings: Minimum IP20, certified to CSA-C22.2-60529.
 - .3 Dimensions: 71-mm x 114-mm (2.78-in x 4.5-in)
 - .4 Features: Neoprene gasket. Filter to protect sensor from contaminants, 100-µm (3.94-in/1,000), sintered stainless steel.
 - .5 Ratings
 - .1 Ambient Temperature: 0-°C to 70-°C (32-°F to 158-°F)
 - .2 Ambient Humidity: 0-%RH to 95-%RH non-condensing.
 - .5 Performance
 - .1 Transmitter Accuracy: +/-0.1-% of span, including linearity.
 - .6 Certifications, Listings and Registrations
 - .1 EUL-RoHS compliant.

2.14 TEMPERATURE TRANSMITTERS - LIQUID

- .1 Provide as indicated.
- .2 Manufacturers:
 - .1 Greystone Energy Systems Inc., TE500C/511C/512C Series
- .3 Features
 - .1 Transmitter Enclosure: Hinged.
 - .2 Protection Circuitry: Reverse voltage protected and output limited.
- .4 Materials
 - .1 Probe: 304 stainless steel.
- .5 Options
 - .1 Sensor
 - .1 Probe length as required.
 - .2 NTC: NTC thermistor.
 - .1 Accuracy: +/-0.2-°C (-0.4-°F) over range.
 - .3 RTD: Platinum RTD.
 - .1 Accuracy: +/-0.3-°C (+/-0.54-°F) at 0-°C (32-°F).
 - .2 Display
 - .1 LCD: Liquid crystal display of temperature, configurable to display in Celsius and Fahrenheit, minimum 3 digits.
 - .3 Transmitter Enclosure
 - .1 ABS1: ABS enclosure. Minimum IP61, certified to CSA-C22.2-60529.
 - .2 ABS5: ABS weatherproof enclosure. Minimum IP65, certified to CSA-C22.2-60529.
 - .3 GS: Galvanized steel enclosure. Minimum IP50, certified to CSA-C22.2-60529.
 - .4 ALU: Cast aluminum weatherproof enclosure. Minimum IP64, certified to CSA-C22.2-60529.
- .6 Performance
 - .1 Sensor Range Capability: -20-°C to 105-°C (-4-°F to 221-°F)
 - .2 Transmitter Accuracy: +/-0.1-% of span, including linearity.
- .7 Ratings
 - .1 Ambient Temperature: 0-°C to 70-°C (32-°F to 158-°F), or -40-°C to 85-°C (-40-°F to 185-°F) if required by location.
 - .2 Ambient Humidity: 0-%RH to 95-%RH non-condensing.
- .8 Certifications, Listings and Registrations
 - .1 EUL-RoHS compliant.

2.15 ELECTRIC ACCESSORY PRODUCTS

- .1 Signal Isolation Transducers
 - .1 Provide signal isolation transducers for analog output signals to be interfaced as inputs, including to and from controllers and independent control systems.
- .2 Signal Conditioning
 - .1 Provide as required.
- .3 Control Transformers
 - .1 Provide as required.
 - .2 Type
 - .1 Fused or current limiting type.
 - .3 Size: 125-% rated load capacity.
- .4 Power Supplies
 - .1 Provide as required.
 - .2 Type
 - .1 Switching or full bridge rectification.
 - .3 Features
 - .1 Fused.
 - .2 Power disconnect switch.

- .4 Size: 125-% rated load capacity.
- .5 Performance
 - .1 Line Regulation: +0.05-% for 10-% line change.
 - .2 Load Regulation: +0.05-% for 50-% load change.
 - .3 Ripple and Noise: 1-mV rms, 5-mV peak to peak.
- .5 Wiring and Cables
 - .1 Provide interfacing as required.

2.16 PNEUMATIC ACCESSORY PRODUCTS

- .1 Air Static Pressure Probes
 - .1 Provide as required, including accessories, mounts.
 - .2 Insertion depths and arrangements as required for high performance and limited by service size.
 - .3 Sensors
 - .1 Stainless steel static pressure tips.
 - .2 Mounting flanges with integral rubber gasket.
 - .4 Gauges and Switches
 - .1 Brass static pressure tips.
 - .2 Angled tip.
 - .3 Minimum 4 radially drilled 1-mm (0.040-in) diameter sensing holes.
- .2 Electronic/Pneumatic Transducers
 - .1 Provide as required.
 - .2 Manufacturers
 - .1 Greystone Energy Systems Inc.
 - .2 Johnson Controls, Inc.
 - .3 Features
 - .1 Manual output adjustment.
 - .2 External replaceable supply air filter.
 - .3 Pressure gauge.
- .3 Tubing and Piping
 - .1 Provide as required.
 - .2 Materials
 - .1 Copper: Provide unless otherwise required.
 - .2 Plastic: Flame retardant PVC tubing with minimum burst gauge pressure of 1.4-MPa (200-psi) at 80-°C (176-°F).

2.17 FIRE STOPPING AND SMOKE SEALS

- .1 Provide as required.
- .2 To Section 23 05 15 Common Piping and to Section 26 05 00 Wiring and Cables.

PART 3 EXECUTION

3.1 EXAMINATION

- .1 Complete the following examination activities within 5-days after the date of execution of Contract.
 - .1 Verify type, quantity and condition of existing devices and controllers.
 - .2 Confirm the suitability of the points for the specific installation, purpose, goal, and final system installed.
 - .3 Complete a detailed investigation of existing network architecture and network wiring topology.
 - .4 Submit written notification of the results of the investigation.
- .2 Submit relocation plan, and obtain approval before relocating services, panels, or equipment not indicated.
- .3 Complete sufficient examination of existing controllers or equipment ladder logic, including modifications, to properly interface and interlock controls.

3.2 COMMON EXECUTION REQUIREMENTS

- .1 Location
 - .1 Install devices and related accessories in locations as indicated.
 - .2 Install devices in accessible locations.
 - .3 Install devices and related accessories in local enclosures as required, including when any of the following occur:
 - .1 Device housing is not suitable as an enclosure rated as required.
 - .2 Device ancillaries including wiring is not rated as required.
 - .3 Device wiring raceway requirements cannot be met with device housing.
 - .4 Device location would limit access to device.
 - .5 Device location is not acceptable for other equipment and components due to limitations of equipment or potential operating environment.
 - .4 Maintain minimum 610-mm (2-ft) clearance from equipment that may emit electromagnetic fields, including transformers, coils.
- .2 Provide hard wired interlocks for safety devices, including on equipment, components, devices, controllers.
- .3 Interfacing
 - .1 Controls may require interfacing, including to equipment, components, devices, controllers. Interfacing requirements apply whether or not specific control or end device(s) is provided.
 - .2 Investigate and report on failed or deficient functionality and capability of existing products, including safeties and interlocks.
 - .3 Interfacing to be completed in a manner that maintains functionality and capability including safeties, interlocks, whether or not these items were previously functional.
 - .4 Provide instructions from manufacturers of new and existing products on requirements for interfacing. Manufacturers to complete site investigations as required.
- .4 Provide additional components as required, including additional points, end devices, power supplies, signal conditioning, interfaces, piping, tubing, wiring.
- .5 Complete configuration on site, including settings, programming and user interface.
- .6 Configure device scale ranges to suit the application, including operating temperatures, pressure or vacuum, with readings at approximately mid-point on the scale where applicable.
- .7 Provide, test, and calibrate devices as required, including sensors, transmitters, voltage and current measurement devices, analog to digital converters, and other input devices.

3.3 DEVICE APPLICATION - DUCT

- .1 Mount duct sensors in an electrical box through a hole in duct.

3.4 DEVICE APPLICATION - ZONE

- .1 Mount sensors on surfaces or supports as required. Subject to Owner approval.
- .2 Relocate existing devices into zone area as required, including devices incorrectly located in ceiling plenums and ceiling areas.

3.5 DEVICE MOUNTING - IMMERSION STYLE

- .1 Provide thermowells as required.

3.6 DEVICE TYPE - ACTUATORS

- .1 Configure as required, including rotation, rotation limits, fail position and direction, speed, signal.
- .2 Mount such that rotation indicator is visible from floor.
- .3 Feedback Signal: When not connected directly to a controller input, wire back to a terminal strip in the control panel or relevant enclosure for trouble-shooting purposes.

3.7 DEVICE TYPE - CONCENTRATION

- .1 Disable automatic calibration features native to device.

3.8 DEVICE TYPE - ELECTRICAL CURRENT

- .1 Motor Status: Calibrate to indicate positive run status only when motor is operating under load. Account for motors running under no or low load. A motor running with a broken belt or coupling shall indicate a negative run status.

3.9 DEVICE TYPE - ELECTRIC SWITCHES

- .1 Contactors
 - .1 Install as required.
- .2 Relays
 - .1 Install as required.
 - .2 Locations
 - .1 Mount relay in equipment or component wiring compartments or chases. Otherwise mount relay remotely to nearest accessible junction box.
 - .2 When mounted in wiring compartments or chases of heating equipment or component without separation between control and power circuits, provide Class 1 circuit for control circuit including Class 1 transformer, and raceway within enclosures.

3.10 DEVICE TYPE - LEVEL - LIQUID

- .1 Mounting height as required in consideration of range for overflows, debris buildup.
- .2 Install to provide required straight services lengths upstream and downstream of device. Modify services as required, including piping.

3.11 DEVICE TYPE - OTHER SWITCHES

- .1 Install as required.
- .2 Locate in appropriate locations for full performance and protection of systems.
- .3 Provide interlocks as required.

3.12 DEVICE TYPE - PRESSURE

- .1 Unless otherwise indicated, locate devices, including tubing and piping and reference ports, at locations most appropriate for performance and optimum system efficiency. As approved by Engineer. Requirements include:
 - .1 Suitable for intended use and effect.
 - .2 Device concealment in specific locations, including occupied zones.
 - .3 Device mounting locations, including at farthest end of distribution system.
 - .4 Accounting for impact on pressure readings due to stack effect, wind, zone pressure. Protection from pressure variations and moving air including ventilation, stack effect, wind effects, elevator doors and lobbies, as well as to protect from debris and insects.
 - .5 Reference ports to various locations that may be distinctly remote from device. Reference ports to be at same height at device, including when reference ports are to outdoors.
 - .6 Device mounting in locations for easy reading of any displays.
- .2 Provide additional devices and reference tubing and piping components as required, including pitot tubes and probes.
- .3 Tubing: Mount outdoor reference tubing and piping in enclosures, minimum NEMA Type 4 rated to NEMA-250, protected from sun, reflection, wind, weather, and other heat or vent sources including ventilation, combustion, piping, plumbing.
- .4 Piping
 - .1 Pipe connections to manufacturers recommended location for pipe orientation.
 - .2 Provide minimum 50-mm (1/2-in) lines to device. Reduce at device.
 - .3 Provide enclosure mounted tee fittings and shutoff valves in the high and low sensing pick-up lines to allow permanent, easy-to-use testing, calibration, and maintenance.
- .5 Documentation: For devices with multiple connections and shutoff valves, document various shutoff valve modes for specific purposes, including mode title, valve tags, valve positions. Document to be complete with laminated chart.

3.13 DEVICE TYPE - SIGNALLING

- .1 Audible Signalling: Where not indicated, locate audible signalling in suitable locations for performance including low sound interference and dampening.
- .2 Visible Signalling: Where not indicated, locate visible signalling in suitable locations for performance including high visibility between visible signalling and in areas that may be occupied including behind equipment and at locations requiring service.
- .3 Where indicated, adjust location as required for performance upon approval from Engineer.

3.14 DEVICE TYPE - TEMPERATURE - DUCT

- .1 Where specific type and options not indicated, select the following probe types:
 - .1 Provide multi-point flexible probe (MPP-F) sensors for ductwork greater than 1.5-m (5-ft) in width or height and greater than 1.5-m² (15-ft²), or in conditions with unevenly distributed air, including air temperature stratification and air turbulence.
 - .2 Provide multi-point rigid probe (MPP-R) sensors for ductwork less than 1.5-m (5-ft) in width or height but greater than 1.0-m (3-ft) in width or height, or in conditions with unevenly distributed air, including air temperature stratification and air turbulence.
 - .3 Otherwise, provide single point rigid probe (SPP-R) sensors.
- .2 Increase quantity of devices per indicated point to suit duct size and achieve performance as determined by Engineer.

3.15 DEVICE TYPE - TEMPERATURE AND HUMIDITY

- .1 Seal openings including signal wiring and cable to prevent air from other areas affecting the readings.
- .2 Seal sensors located on walls and other surfaces to prevent air currents from within surface impacting sensor readings.

3.16 ELECTRIC ACCESSORY PRODUCTS

- .1 Signal Isolation Transducers
 - .1 Install as required.
- .2 Signal Conditioning
 - .1 Install as required.
- .3 Control Transformers
 - .1 Install as required.
- .4 Power Supplies
 - .1 Install as required.
- .5 Wiring and Cables
 - .1 Install as required.
 - .2 Make ready for raceway connections for wiring and cables unless otherwise indicated.

3.17 PNEUMATIC ACCESSORY PRODUCTS

- .1 Electronic/Pneumatic Transducers
 - .1 Install as required.
- .2 Tubing And Piping
 - .1 Protection: Mechanically protect tubing and piping from mechanical damage.
 - .2 Gauges and Filters: Provide pressure gauges on the output side of each pneumatic output point. Provide disposable cartridge filter (in clear plastic casing) at input (main air side) of each electro-pneumatic transducer (EPT).
 - .3 Supports and Hangers: Fasten tubing and piping to walls, ceilings, ductwork, supports, and enclosures as required.
 - .4 Labelling: Label tubing and piping in same manner as wiring and cables to Section 26 05 00 Wiring and Cables. Follow existing labelling convention if possible.

3.18 OTHER ACCESSORY PRODUCTS

- .1 Zone Device Guards
 - .1 Install as required. Obtain approval from Owner.
- .2 External Manual Override Stations
 - .1 Install as required.

3.19 FIRE STOPPING AND SMOKE SEALS

- .1 Install as required.
- .2 To Section 23 05 15 Common Piping and to Section 26 05 00 Wiring and Cables.

3.20 LABELLING

- .1 Labelling to match existing labelling scheme if possible and if approved by Owner, otherwise to meet Owner requirements.
- .2 Label with point or controls or network name with 3 rows of characters per label.
- .3 Devices
 - .1 Manufacturers
 - .1 Thomas & Betts Limited
 - .2 Brady Worldwide, Inc.
 - .2 Type: 12 character metalized polyester labels.
 - .3 Colours: Black lettering on clear backing.
- .4 User Interfaced Devices
 - .1 Legends: When devices have multiple buttons or screen interface, provide legend for users as required by Owner.
 - .1 Type: Lamacoid.
- .5 Ceiling Labelling
 - .1 Provide coloured labels on ceiling surfaces to indicate equipment and components including the following. Colours indicated are indicative of requirements and Owner may change for each type of equipment or component.
 - .2 Provide labels as acceptable to Owner, including label type, material, size and colour. Owner may require lamacoids, adhesive labels with text, adhesive labels with no text.
 - .3 Mark each label as acceptable to Owner, including equipment label, type, power circuit.

3.21 FIELD QUALITY CONTROL

- .1 Field test each system independently and then in unison with other related systems, to ASHRAE-G-11, including non-HVAC systems and points.
- .2 Complete point by point tests on all points and devices, including digital, analog, input, output, network, independent devices.
 - .1 Test and calibrate network points.
 - .2 Test and calibrate analog input points.
 - .3 Test each digital input switching contacts, and digital input signal.
 - .4 Test each digital output to ensure proper operation, fail mode, and lag time.
 - .5 Test each analog output to ensure proper operation of controlled devices.
 - .6 Stroke actuated devices fully open and fully closed. Verify installation including tight closure, mechanical limit setting, and proper spring return orientation.
 - .7 Test and verify fail modes, interlocks, and other software modes of operation.
- .3 Adjust, test, and reconfigure affected systems to maintain original operation.
- .4 Correct problems with affected systems during the warranty period.
- .5 Submit test reports as required.
- .6 Fire Testing: Provide assistance as required for the next scheduled fire test.

3.22 ADJUSTING

- .1 Set and adjust as required.
- .2 Adjust the following as required:
 - .1 Device settings and adjustable parameters.
 - .2 Device calibration.
- .3 Fluid Level, Low Fluid, Flow Sensors and Switches
 - .1 Set and coordinate settings with requirements of system and other flow devices including pumps and control valves.
 - .2 Allow for 4 additional site visits after start-up and during Warranty Period for adjustments to flow sensors and switches during system operation and shutdown to achieve desired operation under various conditions including peak and seasonal loads.

3.23 CLOSEOUT ACTIVITIES

.1 Demonstration

- .1 Demonstrate operation of systems including sequence of operations in regular and emergency modes, under normal and emergency conditions, start-up, shut-down interlocks and lock-outs.

END OF SECTION 25 30 00

SECTION 25 50 00 BUILDING CONTROL SYSTEMS

PART 1 GENERAL

1.1 SECTION INCLUDES

- .1 Building control and automation hardware and software, controllers.

1.2 REFERENCED DOCUMENTS

- .1 ASHRAE-135: ANSI/ASHRAE-135-2012 BACnet - A Data Communication Protocol for Building Automation and Control Networks.
- .2 ASHRAE-G-11: ASHRAE-G-11-2009 Guideline on Field Testing of HVAC Controls Components.
- .3 NEMA-250: NEMA-250-2014 Enclosures for Electrical Equipment (1000 Volts Maximum).

1.3 DEFINITIONS

1.4 INTENT

- .1 Provide design, construction, and commissioning services required to provide a system that meets the specified intent and requirements.
- .2 BAS Expansion
 - .1 Expand existing BAS as indicated.
 - .2 Scope of expanded BAS is comprised of the following:
 - .1 Scope of existing BAS in its entirety, including physical signals, virtual variables, sequences, graphics screens, trend logs, and alarms.
 - .2 New physical signals, virtual variables, sequences, graphics screens, trend logs, and alarms.
 - .3 Other indicated requirements.
 - .3 Sequences
 - .1 Provide new sequences as indicated.
 - .2 Modify existing sequences as required.
 - .4 GUI
 - .1 Create new graphical displays for new Work.
 - .2 Incorporate new Work into existing graphical displays.
 - .5 Trend Logs
 - .1 Provide trend logs for new Work.
 - .2 Provide trend logs for existing BAS as required, including updating and creating new trend logs.
 - .6 Alarms
 - .1 Provide new alarms for new Work.
 - .2 Provide alarms for existing BAS as required, including updating and creating new alarms.
 - .7 Provide new features as indicated.
 - .8 Where the existing BAS performance or features conflict with specified performance or features, the more stringent requirements shall take precedence.
 - .9 Contractor agrees to assume all responsibility for assessing extent, nature and capabilities of the existing system, and waives future claims against errors or omissions in documentation or graphics screens.
 - .10 Contractor acknowledges that depictions of extent of existing system contained within Contract Documents are for the sole purpose of providing a basis for comprehending the prescribed additional functionality, and not to provide an accurate or comprehensive description of existing BAS.

1.5 SUBMITTALS FOR ACTION

- .1 Product Data
 - .1 Manufacturers' product literature, specifications, and datasheets. Include the following information:
 - .1 Product characteristics.

- .2 Performance criteria.
- .3 Options.
- .4 Limitations.
- .5 Photographs.
- .6 Supplier information.
- .2 Performance criteria for end devices includes accuracy, operating environment tolerances, and stability criteria.
- .3 Detailed bill of material list for each system or application, identifying quantities, part numbers, descriptions, and optional features.
- .2 Shop Drawings
 - .1 Physical System
 - .1 Control system in its entirety, distinctly indicating existing parts and new Work.
 - .2 Control system network architecture diagrams including controllers, interconnections, repeaters and network interfaces.
 - .3 Control panel and controller schedules.
 - .4 Site and floor plan drawings showing location of system components.
 - .5 System schematics and flow diagrams indicating point location, name, and hardware address.
 - .6 Diagrams indicating power wiring for all controllers and devices. Include panel numbers, panel locations, circuit breaker numbers, and wiring and conduit details.
 - .7 Points list describing hardware location, function, signal conditioning, and end devices for each point.
 - .2 Programming
 - .1 Details of control system programming including:
 - .1 Sequences of operation.
 - .2 Descriptions of variables and constants.
 - .3 Software architecture.
 - .4 For sequential-style programming languages, provide commented line by line listings of code.
 - .5 For graphical-based programming languages, provide commented logic drawings.
 - .3 Details of control system data visualization and format including:
 - .1 Proposed trend log point grouping and scaling.
 - .2 Archive data format.
 - .4 Sample of archived data in specified format.
 - .1 Minimum 24-hour duration.
 - .2 All required points.
 - .5 Schedules
 - .1 Room schedules including separate line items for zone equipment and components indicating location and associated control points.
 - .2 Equipment and component schedules for settings and parameters.
 - .6 Wiring and Ladder Logic
 - .1 Diagrams detailing control system network interfaces, interface devices, and hardware interlocks for all equipment affected by Work.
 - .2 Diagrams describing existing undocumented control system network interfaces, interface devices, and hardware interlocks.
 - .7 Interlocks: Schematic and wiring diagrams detailing electrical interlocks and life safety system interfaces.
 - .8 Labels: Scaled drawings indicating locations, as well as details of labelling including dimensions, layout, lettering, font, spacing, colours.
 - .3 Samples
 - .1 Zone Devices: Submit samples of end devices, including zone temperature, humidity, and pressure sensors, to be located in occupied areas or visible from exterior.

1.6 SUBMITTALS FOR INFORMATION

- .1 Existing BAS
 - .1 Detailed English language description of existing control sequences.
 - .2 Complete list of existing BAS points.
- .2 Certificates
 - .1 Conformance: BACnet Protocol Implementation Conformance Statement to ASHRAE-135 for all BACnet devices and controllers.
 - .2 Letter from control system manufacturer certifying proposed controllers are fully compatible with each other or any parts of existing system being reused where allowed.
- .3 Manufacturer Information
 - .1 Operating and Maintenance Manuals
 - .2 Installation Instructions
- .4 Testing Report: A report detailing the results of testing activities including the following:
 - .1 Dates of testing activities.
 - .2 Names and contact information of testing technician.
 - .3 Point Calibration Results: Include points and devices tested, description of testing method, observations including point values, measured values, discrepancies, and a description of corrective action taken.
 - .4 Output Testing Results: Include points and devices tested, description of testing method, observations including point values, measured values, discrepancies, and a description of corrective actions taken.
 - .5 Failure Mode Test Results
 - .6 Software State Test Results
 - .7 Interlocks Test Results
 - .8 Completed Testing Check List
- .5 Test and Evaluation Reports
 - .1 Report on air terminal box test, including:
 - .1 Hardware address of distributed controller.
 - .2 List of rooms served.
 - .3 Location of temperature sensors.
 - .4 Programmed maximum and minimum flow settings.
 - .5 Measured flow rates at maximum and minimum flows, per box.
- .6 Periodic Inspection Reports
 - .1 Provide written reports for each required post construction inspection including:
 - .1 Date of inspection.
 - .2 Climate conditions.
 - .3 Notes.
 - .4 Trend log printouts.
 - .5 Summary of adjustments or changes made.
 - .6 Updated documentation.
 - .7 Updated electronic copies of documentation.
- .7 Marked Up Drawings
 - .1 Marked up drawings indicating extent of differences between issued Drawings, building drawings and actual as-built conditions.

1.7 SUBMITTALS FOR CLOSEOUT

- .1 Operating and Maintenance Data
- .2 Electronic Data
 - .1 Editable electronic files for drawings in both AutoCAD and Visio format.
 - .2 A duplication of the contents of the manual in Adobe PDF format.
 - .3 Archive copy of site-specific databases, software, configuration and sequences.
 - .4 Electronic copy of controller database including point configuration, sequences, and other programmable parameters.
- .3 Spare Parts

- .1 Keys: 4 sets of common keys to control system enclosures.
- .4 Tools and Software
 - .1 Licenses to use and own proprietary software and documentation for an unlimited duration without additional fees. Licenses shall include required software updates to maintain functionality.
 - .2 Copies hardware security devices, documentation.
 - .3 Digital copies of software.
 - .4 Provide control system software and tools needed for full functional use, including programming and configuration of new and existing controllers, programming changes, network management and expansion, and GUI use and development. Provide training required for use of software and tools.
 - .5 Provide system and programming manuals that describe system overview, programming and testing, in hard copy and electronic copy. Manuals to include detailed description of each software feature including:
 - .1 Editing and writing control programs
 - .2 Reading or modifying printout and logs
 - .3 Adding, deleting and modifying user password
 - .6 Provide highest level passwords and security access to hardware functions, configurations, and upgrades.

1.8 QUALITY ASSURANCE

- .1 Installer Qualifications
 - .1 Control System Configuration
 - .1 Regularly engaged in the engineering, programming, installation and service of similar systems.
 - .2 Office within a 150-km radius of Site, that offers complete maintenance and support services on a 24-hour/day, 7-days/week, 365-days/year basis. This office shall have direct access to or inventory of spare parts and all necessary test and diagnostic equipment required for installation, commissioning and servicing.
 - .2 GUI Mock-up
 - .1 Prepare working mock-up of GUI screens.

1.9 ADMINISTRATIVE REQUIREMENTS

- .1 Pre-Submittal Review Meeting
 - .1 Schedule and conduct pre-submittal areview meeting as required, or upon request. Adhere to project meeting procedures as described in Section 01 00 00 Project Procedures.
 - .2 Meet with Engineer to review Drawings and Specifications in detail before preparation of submittals.
 - .3 Walk through products and execution requirements in detail, and provide commentary to convey understanding of requirements.
 - .4 Notify Engineer of problems or concerns with meeting design intent.
 - .5 Follow request for clarification procedures to clarify issues regarding design intent.
 - .6 Provide written detailed justification for BAS network architecture when requested by Engineer.
- .2 Phase In Coordination Meeting
 - .1 Coordinate and hold a phase in meeting with Owner to discuss and plan installation and migration plan from old control system to new control system.
- .3 Field Documentation Review
 - .1 Arrange meeting no later than 1 week after shop drawings have been submitted to review field documentation plan with Owner.
 - .2 Provide a description of the following for approval:
 - .1 Colour coding scheme for communication, power, and control wiring.
 - .2 Labelling scheme for all wiring.
 - .3 Point naming conventions.

- .4 Panel, equipment, and system naming conventions.
- .5 Field labelling names, format, and information.
- .4 Control Sequences Configuration Review Meeting
 - .1 Schedule and conduct sequences configuration review meeting. Adhere to project meeting procedures as described in Section 01 00 00 Project Procedures.
 - .2 Meet with Engineer to review sequences in detail before implementation.
 - .3 Provide samples and mockups to demonstrate how users will interact with lighting control system.
 - .4 Provide written detailed justification for choice of control strategy when requested by Engineer.
 - .5 Demonstrate how intent and programming requirements will be achieved.
 - .6 Document decisions and settings, and revise written sequences as required.
- .5 Trend Log Data Review
 - .1 Trend log data is critical to commissioning and correction activities.
 - .2 Submit sample trend log data in the following electronic format:
 - .1 File Format: Microsoft Excel
 - .2 Minimum Interval: 1-min
 - .3 Points: Physical Analog and Digital Input and Output Points
 - .4 Format: Database quality table format, having columns containing point names and rows containing each sample, with no gaps, column shifts, or text between rows.
 - .5 Data shall be obtained through direct database query. Manual editing of text reports shall not be accepted.
- .6 Testing Plan Review
 - .1 Submit Testing Plan for approval 20-days prior to testing.
 - .2 Revise the Testing Plan as required to the satisfaction of the Engineer.
 - .3 Submit the Testing Report demonstrating results of testing activities.
- .7 Other
 - .1 Notify Engineer of problems or concerns with meeting design intent.
 - .2 Follow request for clarification procedures to clarify issues regarding design intent.
 - .3 Submit work in progress sequences, and walk through programming logic with Engineer upon request.

1.10 WARRANTY

- .1 Special Warranty
 - .1 Include replacement of failed reused controllers, end devices, and sensors during Warranty Period.
 - .2 Include modifications and adjustments during Warranty Period, including logic, and sequences, settings, limits, tuning of PID controllers.
 - .3 Provide the following throughout the Warranty Period to inspect control system operation and performance, including under varying climate conditions, loads, schedules, modes.
 - .1 4 site visit(s) per year, evenly scheduled throughout each calendar year unless modified by Owner, each site visit for 4-hours.
 - .2 12 remote access session(s) per year, evenly scheduled throughout each calendar year, each remote access session for 2-hours
 - .4 Update site documentation to reflect current system configuration, including paper and electronic versions as required.
 - .5 Create backup copies, complete with version designations, notations, modifications, changes.

PART 2 PRODUCTS

2.1 EXISTING PRODUCTS

- .1 Provide functionality to use and share information from and to existing BAS for control and display purposes:
 - .1 Existing Building Controls System
 - .1 Alerton Ascent
- .2 Devices: Devices approximately as indicated. Confirm quantities and details by site investigation and review of available documentation.

2.2 SYSTEM ARCHITECTURE

- .1 Intent
 - .1 Design control system architecture in a logical manner, considering future expansion and changes.
 - .2 Design control system to be distributed such that disconnection of each system or space from network does not interfere with local space control with exception of specific global variables limited to:
 - .1 Centralized functions, including schedules.
 - .2 Centralized devices including sensors, overrides.
 - .3 Design control system to be have fully programmable control over individual addressable devices.
- .2 System
 - .1 Manufacturers
 - .1 Provide system hardware and software from the same manufacturer and capable of being serviced from a single vendor.
 - .2 Features
 - .1 System shall be modular in nature, and shall permit expansion of both capacity and functionality through the addition of sensors, actuators, controllers and operator devices.
 - .2 System architectural design shall eliminate dependence upon any single device for alarm reporting and control execution. The failure of any single component or network connection shall not interrupt the execution of control strategies at other operational devices.
 - .3 Organize sub-networks logically by floor or area such that sub-networks match logical physical building areas.
 - .4 Provide 20-% additional capacity on controllers, gateways, and bridges to accommodate changes and expanded points.
 - .5 GUI must appear as a single integrated system, accessible and controlled by a single application.
 - .6 System components, including controllers, devices, power supplies, signal conditioning hardware, wiring and other equipment, shall be rated to operate properly in the extremes of the environment that they are to be located in.
 - .3 Performance
 - .1 System Scan Rate: System capable of refreshing physical point values once every 2-sec.
 - .2 GUI Refresh Rate: Maximum 2-sec fully refreshed screen including data from launch of any screen.
 - .3 Memory: Provide sufficient controllers, memory, and/or servers as required.
 - .4 System Management: Provide minimum supervisory and management functionality as defined by BACnet Advanced Workstation (B-AWS) to ASHRAE-135.
 - .5 Synchronization
 - .1 Controllers relying on real time information (for scheduling, trending, etc.) shall be periodically, automatically synchronized with one other.
 - .2 Controller real time clocks to be periodically, automatically synchronized with a third party Network Time Server, such as ntp.com.

- .6 Integration
 - .1 Provide gateway devices or controllers having on board gateways to convert existing proprietary protocols to native BACnet to allow BACnet access to existing proprietary controllers.
 - .2 Provide BACnet Protocol Implementation Conformance Statement for gateways.
 - .3 Gateways shall be tested and listed on BACnet Testing Laboratories website for all functions available from proprietary network controllers.

2.3 COMMON PRODUCT REQUIREMENTS

- .1 Addressing: Individually addressable and reconfigurable addresses from system.
- .2 Memory: Retain settings in non-volatile memory.
- .3 Settings Maintained: Maintain settings and operation on loss power, network, communication to controllers.
- .4 Certifications, Listings and Registrations
 - .1 Assembly: Listed to UL-916.
 - .2 Materials: To EUL-RoHS.

2.4 SUPERVISORY PLATFORM

- .1 Provide as required.
- .2 Manufacturers
 - .1 Alerton, Ascent

2.5 CONTROLLERS

- .1 Provide as required.
- .2 Manufacturers
 - .1 Alerton, Ascent
- .3 Minimum Functionality
 - .1 Building Controllers
 - .1 To BACnet Building Controller (B-BC) to ASHRAE-135.
 - .2 Advanced Application Controllers
 - .1 To BACnet Advanced Application Controller (B-AAC) to ASHRAE-135.
 - .3 Application Specific Controllers
 - .1 To BACnet Application Specific Controller (B-ASC) to ASHRAE-135.
 - .4 DS-COV-B (Data Sharing, Change of Value Provider) to ASHRAE-135.
 - .5 Intrinsic alarm and event management to ASHRAE-135.
 - .6 Support for calendar objects for scheduling.
- .4 Communication Protocols
 - .1 BACnet.
 - .2 Certifications and Standards
 - .1 BACnet Protocol Implementation Conformance Statement for all BACnet objects as required to meet indicated intent and performance requirements.
 - .2 Tested and listed on BTL website.

2.6 CONTROL ENCLOSURES AND PANEL ASSEMBLIES

- .1 Provide enclosures for controllers and related components, and for control devices in service areas or not protected from damage.
- .2 Features
 - .1 To NEMA-250, rated for the environment as required.
 - .2 Provide ventilation, heating, and humidity conditioning as required.
 - .3 Provide hinged, enamelled steel enclosures, and locking slotted flush latch for control panel assemblies.
 - .4 Provide convenience 120-VAC duplex receptacle in each enclosure, complete with fused on/off power switch, and GFCI protection, except for the following:
 - .1 Enclosures for controllers serving unitary equipment and not located in service areas.
- .3 Layouts

- .1 Securely mounted components.
 - .2 Neat and tidy layouts including cables and wiring.
 - .3 Cables and wiring to be concealed using slotted PVC wiring ducts complete with covers.
 - .4 Cables and wiring to be colour coded and labelled.
 - .5 Mount controller LCD or LED display modules flush in panel faces unless otherwise indicated.
- .4 Existing Enclosures and Panels
- .1 Remove obsolete components including controls and wiring when interfacing to existing panels.

2.7 CONFIGURATION

- .1 Provide control system capable of being configured fully functional for the following features:
 - .1 Alarms and Events
 - .2 Schedules
 - .3 Trend Logs
 - .4 Reports

2.8 GRAPHICAL USER INTERFACE

- .1 Intent
 - .1 Provide GUI to allow users/operators to easily view, control, investigate and troubleshoot controlled systems, equipment and components, through uncluttered graphics screens, with consistent layouts, use of colours and animation, with alarming and data visualization features. Includes mimicking full functionality of control system, including points, devices, modes, operations, overrides.
 - .2 Coordinate site and remote access with Owner's information technology staff.

PART 3 EXECUTION

3.1 EXAMINATION

- .1 Existing System Investigation
 - .1 Complete the following examination activities within 20-days after the date of execution of Contract.
 - .1 Verify type, quantity and condition of existing end devices and controllers.
 - .2 Confirm the suitability of the points for the specific installation, purpose, goal, and final system installed.
 - .3 Complete a detailed investigation of existing network architecture and network wiring topology.
 - .4 Photograph, document and submit descriptions of existing controllers and network components, including:
 - .1 Main controllers.
 - .2 Main equipment controllers.
 - .3 Terminal component controllers, including air terminals.
 - .4 Panels.
 - .5 Network components.
 - .5 Submit written notification of the results of the investigation.
 - .2 Submit relocation plan, and obtain approval before relocating services, panels, or equipment not indicated.
 - .3 Complete sufficient examination of existing controls system, including controllers, devices, sequences, including modifications, to properly implement replacement controls including functionality that is not currently documented.
 - .4 Investigate and review point mapping and point naming convention(s).
 - .5 Investigate entire existing control system to verify as-built condition. Mark up copy of existing existing control system drawings or create new drawings as required to indicate as-built conditions of the existing control system including the following:

- .1 Network architecture.
- .2 Panel types and locations.
- .3 Points list.

3.2 COMMON EXECUTION REQUIREMENTS

- .1 Provide additional components as required, including repeaters, gateways, interfaces and other equipment.
- .2 Locate control system components in accessible local enclosures.
- .3 Complete configuration on site, including programming and GUI.
- .4 Provide hard wired interlocks between equipment and safety devices.
- .5 Access: Provide passwords and software required to allow full read and write access to all control system features.
- .6 Provide point naming convention(s) to Owner requirements.
 - .1 Match or improve upon existing point mapping and point naming convention(s).
 - .2 Ensure consistency.
 - .3 Ensure point naming includes information related to input vs. output, analog vs. digital, variables and setpoints, physical device vs. interface vs. mapped object.

3.3 CONTROL ENCLOSURES AND PANEL ASSEMBLIES

- .1 Locate enclosures in accessible locations within service areas, except for the following:
 - .1 Controllers serving unitary equipment and not located in service areas.
- .2 Locate enclosures at an elevation of not less than 610-mm (2-ft) from the bottom edge of the panel to the finished floor, subject to Owner approval.
- .3 Ensure panel locations do not interfere with existing electrical panel clearance requirements.

3.4 INTERFACING WITH OTHER NETWORKED CONTROLLERS

- .1 Other networked controllers includes various controllers as indicated, including equipment, components, devices, other controllers.
- .2 Map all networked points and interfacing points back to supervisory controller with required communications protocol, including for interfacing to equipment, components, controllers, devices, other controllers.
 - .1 Provide read and write capability in both supervisory controller and other networked controllers for required parameters and objects, including user adjustable variables. Follow control system point naming convention.
 - .2 For other points, maintain other networked controller point naming convention.
 - .3 Coordinate remote device point naming conventions for consistent point naming.

3.5 POWER SUPPLY SOURCES

- .1 Provide power supplied from building emergency power supply for the following:
 - .1 Controllers
 - .2 End Devices
 - .3 Communications Hardware
- .2 Provide uninterruptable power supply for the following:
 - .1 Workstations
 - .2 Servers
 - .3 Communications Hardware
- .3 Provide control power from a power source that originates from the panelboard, splitter, or switchboard that directly feeds equipment being controlled.
- .4 Provide automatic protection for electronic equipment from power line transients and surges.

3.6 WIRING AND CABLES

- .1 Make ready for conduit connections for wiring and cables unless otherwise indicated.
- .2 Trough Boxes: Use trough boxes to pull field wiring to central panels. Include minimum 610-mm (2-ft) of extra field wire length in the box.
- .3 Connections: Terminate signal wires at controllers with screw terminals. Terminate 1 wire to each BAS Controller terminal.

- .4 Location: Terminate communications wiring leading to computers, office areas, or other finished areas in a junction box. Match cover plates and wall jacks with existing décor. Refrain from wiring through holes in surfaces including walls or from ceiling plenums.
- .5 Clearance: Maintain minimum 610-mm (2-ft) clearance from equipment that may emit electromagnetic fields, including lighting ballasts.
- .6 Power: Use dedicated circuits for power to controllers, power supplies, and electronic equipment.
- .7 Labelling: Label wiring and cables in same manner as wiring and cables to Section 26 05 00 Wiring and Cables. Follow existing labelling convention if possible.

3.7 LABELLING

- .1 Controllers and Panels
 - .1 Label with nameplate identifying controller and equipment/system (if applicable).
 - .1 Minimum 75-mm (3-in) wide by 25-mm (1-in) high.
 - .2 Laminated plastic with black face and white centre.
 - .3 Letters engraved.
 - .2 Include printed label indicating network address.
 - .3 Include laminated printout of points list for all controllers within panel.
 - .4 Communicate and obtain confirmation of controller naming convention prior to installation.
 - .5 As approved by Owner, create new labelling convention or follow existing labelling convention if possible.

3.8 CONFIGURATION

- .1 Alarms and Events
 - .1 Configure alarms and events to trigger on abnormal operation of equipment and systems including:
 - .1 Failure of life safety devices.
 - .2 Alarm contact closure on equipment or other controllers.
 - .3 Alarm states of equipment connected over network.
 - .4 Equipment failure indicated by status signals not matching start/stop commands.
 - .5 Sensors showing values outside of expected range.
 - .6 Failed sensors, controllers, or communications network.
 - .7 Other alarms and events that are useful in operation and maintenance of building systems.
 - .2 Prioritize alarms as follows:
 - .1 Level 1: Events impacting life safety.
 - .2 Level 2: Events risking damage to building or equipment.
 - .3 Level 3: Events risking disruption to high priority zones or areas.
 - .4 Level 4: Events risking disruption to occupant comfort.
 - .5 Level 5: Other alarms.
 - .3 Alarms shall include information including:
 - .1 Date and time of alarm.
 - .2 Point name, state, and value (if applicable).
 - .3 Priority.
 - .4 Performance
 - .1 Duration between alarm occurrence and alarm annunciation at the local GUI shall not exceed 5-seconds.
 - .2 Duration between alarm occurrence and alarm annunciation at a remote device shall not exceed 60-seconds.
 - .5 Alarm Management
 - .1 Provide full alarm management capabilities including:
 - .1 Security privileges restricting access to alarm management.
 - .2 Functionality to acknowledge, silence, or cancel alarms.

- .3 Functionality to view and sort alarms by date/time, priority, point name, or other alarm attributes.
- .4 Functionality to maintain an audit trail of user activities including user name, date and time of activity, details of alarm (acknowledge, delete, or cancel).
- .6 Remote Notification
 - .1 Provide remote notification to notify remote staff of alarm conditions.
 - .1 Level 1 and 2 Alarms: Default notification to printer(s), pager(s), text message(s), e-mail(s).
 - .2 Level 3-5 Alarms: Default notification to printer(s), e-mail(s).
 - .2 Alarm messages shall contain an informative response message describing the alarm event.
 - .3 Provide additional and separate remote notifications for specific alarm levels when alarm has not been acknowledged within Owner specified time periods.
- .7 Communications
 - .1 Configure messaging system(s) to describe alarm condition, including alphanumeric pages, short message service (SMS) text messages, e-mails.
- .8 Automatic Report Generation
 - .1 Provide automatic report generation capability.
 - .1 Include up to 8 data points per report.
 - .2 Format: Printed, ASCII (comma delimited).
 - .3 Sampling Duration: As required.
 - .4 Reporting Frequency: As required.
 - .5 Report Triggering: Automatically scheduled without user intervention.
- .2 Schedules
 - .1 Provide the following schedule types:
 - .1 Time of Day
 - .2 Weekly Schedules
 - .3 Annual Holiday Schedules
 - .2 Provide the ability to temporarily override schedules with the system automatically resetting to original scheduling after a defined time period.
 - .3 Provide for automatic compensation for periodic time variances, including leap years, daylight savings.
- .3 Trend Logs
 - .1 Provide logs with information grouped by system in a logical manner to meet intent.
 - .2 Provide graphs for trend logs.
 - .3 For staged equipment, provide an analog variable representing the number of active stages to allow graphic representation of staging performance.
 - .4 Provide trend logs to meet the following:
 - .1 Duration: Maintain a continuous record in random access memory.
 - .2 Other Trends Not Listed: As required by commissioning, by Engineer, by Owner.
 - .3 15-minute sampling interval, minimum duration 1-month, for:
 - .1 Zone conditions.
 - .2 Outdoor environmental conditions.
 - .3 User adjustable setpoints.
 - .4 Other slowly changing analog signals and control.
 - .5 Device battery status.
 - .4 5-minute sampling interval, minimum duration 2-weeks, for:
 - .1 Moderate rate changing system conditions.
 - .2 Device position control and feedback, including actuators.
 - .3 Equipment control commands and status.
 - .4 Equipment operating states, including stages.
 - .5 Equipment and system modes.
 - .6 Calculated setpoints.

- .7 Other moderately changing analog signals and control.
- .5 1-minute interval, minimum duration 24-hours, for:
 - .1 Quick rate changing system conditions.
 - .2 Other quickly changing analog signals and control.
- .6 Run-Time Log/ Change of Value Log, minimum duration 1-month, for:
 - .1 Equipment on/off status and digital commands.
 - .2 Other digital points.
 - .3 Equipment and system modes.
 - .4 Daily schedules.
 - .5 Digital alarms.
- .4 Reports
 - .1 Provide graphical plots of trend log reports from random access memory or archive, as required under commissioning requirements, or as requested by Owner or Engineer during Warranty Period.

3.9 GRAPHICAL USER INTERFACE

- .1 Navigation Tree
 - .1 Provide customizable, dockable navigation tree allowing hierarchical links to all controllers, sub-controllers, networked objects, points, systems, layouts, plans, legends.
 - .2 Provide capability for Owner to add custom navigation trees.
- .2 General Screen Layouts: Provide the following for each screen:
 - .1 Accurate to actual layouts and configuration, including for systems, equipment, and components.
 - .2 Organized such that systems, equipment and components are positioned on screen in a manner that is representative of the actual physical location and layout.
 - .3 Points and variables relevant to each system on the graphic, including names of points and variables.
 - .4 Organized as required to ensure information is legible on a single screen when standing 1-m (3.3-ft) away from screen, including avoiding necessity of scrolling or zooming.
 - .5 Functionality for modifying points and variables, including setpoints, states, and overrides, directly from graphics screens, including mimicking actual functionality in physical systems.
 - .6 Indication of points and variables outside of operating ranges and/or in alarm modes to Owner requirements.
 - .7 Indication of differentiation between multiple physical devices controlled by same commands, including graphically linking devices and text descriptions.
 - .8 Display symbols for systems, equipment and components. Graphics configured such that single click on symbols launches more detailed graphical screen on associated equipment and components.
 - .9 Navigation links using consistent graphics, shaded areas, buttons, or hyperlink formatted text to allow user to move from one screen to each related screen with a single click. Each screen to include a return to previous screen link.
 - .10 Additional user interface functions as requested by Owner to improve operations and maintenance activities.
- .3 Legend: Provide legend for symbols and colours used.
- .4 Space Layouts: Provide layouts of site and building, with relevant zone information displayed on each floor, including:
 - .1 Site plan including structures, parking, roads, features, north direction, building numbers, names and functions.
 - .2 Floor layouts including elevators, stairwells, partitions, interior permanent features including minor partitions, room/space numbers, names and functions.
 - .3 Multiple floor plans on a single screen to launch individual floor plans. Allow building operator to navigate through an entire facility both in two- dimensional and three-dimensional multi-floor view, allowing for fast and easy navigation.

- .4 Shaded background colours to distinctly identify spaces and controlled zones served by various systems, equipment and components. For each coloured zone, provide a text description of the system serving the area, linking to other relevant graphics.
- .5 Zone conditions, positioned on each floor plan, and representing actual physical location, linking to other relevant graphics.
- .5 Information Summaries: Provide additional non-graphical based information screens summarizing point information from systems, equipment and components.
 - .1 Group similar or related systems or zone equipment and components into areas or systems on 1 or more screens.
 - .2 Present data aligned in tabular format with each column representing a point value.
 - .3 Include room or space number and description, terminal equipment and component identifier, zone conditions, zone setpoints.
 - .4 Include additional point information indicating status and operation of each point on respective zone equipment and components.
 - .5 Include tables for design settings and values where applicable and as required by Engineer.
 - .6 Link to graphics screen for each terminal equipment.
- .6 Operational Information: Provide the following for each screen:
 - .1 Detailed sequence of operation available for systems, equipment and components. Configure graphics such that single click on graphical screen launches sequence of operation for associated graphical screen. Sequences in editable text based format to allow for ease of future updates.
 - .2 Schedules for systems, equipment and components. Configure graphics such that single click on graphical screen launches summary of schedules for equipment and systems.
 - .3 Trend logs for systems, equipment and components. Configure graphics such that clicking on a trend log icon launches trend logs.
 - .4 Clear written and graphical identification of specific modes, states and operations, overrides.
 - .5 Override selection box, and distinct graphical representation when override is selected.
 - .6 Units of measurement: Metric.
 - .7 Links to configuration and setup.
- .7 Specific Requirements: In addition, ensure to provide the following examples of specifics:
 - .1 Include air terminal settings for minimum and maximum in various modes such as heating and cooling, and show critical zone per system.

3.10 START-UP

- .1 Provide the services of a qualified factory-trained manufacturer's representative to assist with installation and start-up.
 - .1 Submit manufacturer's start-up report, and written certification that system and components have been installed, adjusted and tested in accordance with the manufacturer's recommendations.

3.11 FIELD QUALITY CONTROL

- .1 Field test systems independently and then in unison with other related systems, to ASHRAE-G-11 including:
 - .1 New points, and all points on new controllers.
 - .2 Hard wired controls, safeties, and interlocks for new equipment.
 - .3 Existing points for systems impacted by the Work.
 - .4 Hard wired controls, safeties, and interlocks for parts affected by Work, including systems, equipment, components.
- .2 Complete point by point tests on all points and devices, including digital, analog, input, output, network, independent devices.
 - .1 Test and calibrate network points.
 - .2 Test and calibrate analog input points.
 - .3 Test each digital input switching contacts, and digital input signal.

- .4 Test each digital output to ensure proper operation, fail mode, and lag time.
- .5 Test each analog output to ensure proper operation of controlled devices.
- .6 Stroke actuated devices fully open and fully closed. Verify installation including tight closure, mechanical limit setting, and proper spring return orientation.
- .7 Test and verify fail modes, interlocks, and other software modes of operation.
- .3 Test wireless communications devices.
 - .1 Verify performance of wireless communications, including wireless networks, operations radios, wireless equipment and components.
 - .2 Confirm performance of 25-% of networked wireless devices in the presence of other electromagnetic emitting devices, including wireless, radios, microwave ovens, transformers.
- .4 Adjust, test, and reconfigure the following to maintain original operation:
 - .1 New control points.
 - .2 Existing control points for systems impacted by the Work.
 - .3 New and existing interlocks, third party controllers, and controls
- .5 Correct problems with affected systems during the warranty period.
- .6 Submit test reports as required.
- .7 Fire Testing: Provide assistance as required for the next scheduled fire test.
- .8 Coordinate testing activities with Commissioning activities.

3.12 ADJUSTING

- .1 Adjust configuration as required, including to meet design intent and performance requirements. Adjust configuration including the following:
 - .1 Point calibration.
 - .2 Logic.
 - .3 Sequences.
 - .4 Programming.
 - .5 Settings.
 - .6 Limits.
 - .7 Control loops and logic tuning and parameters.
 - .1 Tune control loops and logic to prevent undershoot and overshoot and to ensure proper response times, including PID control.
 - .8 Trend logs.
 - .9 Graphics.

3.13 CLOSEOUT ACTIVITIES

- .1 Demonstration
 - .1 Demonstrate operation of systems including sequence of operations in various modes including normal and emergency, under normal and emergency conditions, start-up, shut-down interlocks and lock-outs, fail conditions.
- .2 Owner's Instructions
 - .1 On-Line Documentation: After completion of tests and adjustments, provide documentation including as-built information and product data for installation on an Owner designated computer workstation or server.
- .3 Existing Parts to be Removed and Stored on Site
 - .1 Store removed parts including controllers and devices on site at Owner's preferred location. Dispose of parts upon Owner request.

END OF SECTION 25 50 00

SECTION 25 90 00 BUILDING CONTROL SEQUENCES

PART 1 GENERAL

1.1 SECTION INCLUDES

- .1 Control sequences and configuration requirements for controllers, including building automation system, independent controllers, equipment controllers, programmable devices.

1.2 REFERENCED DOCUMENTS

- .1 ASHRAE-62.1: ANSI/ASHRAE-62.1-2016 Ventilation for Acceptable Indoor Air Quality, including User's Manual.
- .2 ASHRAE-90.1: ANSI/ASHRAE/IES-90.1-2016 Energy Standard for Buildings Except Low-Rise Residential, including User's Manual.
- .3 ASHRAE-G-13: ASHRAE-G-13-2007 Guideline on Specifying Direct Digital Control Systems.

1.3 DEFINITIONS

- .1 Refer to other control system and controller sections.
- .2 Air Systems
 - .1 "Exhaust": Air exhausted from indoor zones or at air handler.
 - .2 "Mixed": A mixture of air, usually return air from the zones and outdoor air.
 - .3 "Outdoor": Air from outside the building.
 - .4 "Relief": Excess return air that is exhausted from a supply/return air handler.
 - .5 "Return" and "Entering": Air returning to equipment and ductwork systems, usually from indoor zones.
 - .6 "Supply" and "Leaving": Air leaving equipment and ductwork systems, for the purposes of ventilation and conditioning of air including heating, cooling, humidification, dehumidification.
- .3 Liquid Systems
 - .1 "Heating Boiler Loop" and "Building Heating Loop": "Heating Boiler Loop" refers to the piping directly connected to the heating boilers. "Building Heating Loop" refers to the piping which obtain their heating from the Heating Boiler Loop, and which are typically controlled to a temperature different than the Heating Boiler Loop.
 - .2 "Primary" and "Secondary": When referring to central plant heating or cooling piping, Primary refers to the piping directly connected to the central plant. Secondary refers to the piping which obtain their heating or cooling from the primary loop, and which are typically controlled to a temperature different than the primary loop.
 - .3 "Return" and "Entering": Water entering equipment and piping systems including heating and cooling. Same as glycol and liquid.
 - .4 "Supply" and "Leaving": Water leaving equipment and piping systems including heating and cooling. Same as glycol and liquid.
- .4 Other
 - .1 "Max(A, B, C, ...)": Arithmetic function returning the maximum of all arguments contained within parentheses.
 - .2 "Min(A, B, C, ...)": Arithmetic function returning the minimum of all arguments contained within parentheses.
 - .3 "Sum(A, B, C, ...)": Arithmetic function returning the sum of all arguments contained within parentheses.

1.4 SUBMITTALS

- .1 Refer to other control system and controller sections, including Section 25 50 00 Building Control Systems.

1.5 ADMINISTRATIVE REQUIREMENTS

- .1 Sequences Review Meeting
 - .1 Schedule and conduct sequences review meeting as required, or upon request. Adhere to project meeting procedures as described in Section 01 00 00 Project Procedures.

- .2 Meet with Engineer to review sequences in detail before implementation.
- .3 Walk through sequences in detail, and provide step by step commentary on control assumptions.
- .4 Demonstrate how intent and programming requirements will be achieved.
- .5 Notify Engineer of problems or concerns with meeting design intent.
- .6 Follow request for clarification procedures to clarify issues regarding design intent.
- .7 Submit work in progress sequences, and walk through programming logic with Engineer upon request.
- .8 Provide written detailed justification for choice of control strategy when requested by Engineer.

PART 2 PRODUCTS

2.1 EXISTING PRODUCTS

- .1 Refer to other control system and controller sections, including Section 25 50 00 Building Control Systems.

PART 3 EXECUTION

3.1 EXAMINATION

- .1 Evaluation and Assessment
 - .1 Evaluate and inspect existing controller configuration, performance, and functionality.

3.2 COMMON REQUIREMENTS

- .1 Configure controllers as required to meet design intent, including supervisory controllers, distributed controllers, independent controllers and programmable devices.
- .2 Unless otherwise indicated, controllers shall be selected, installed, and configured to achieve the following control stability and accuracy tolerances:
 - .1 Ambient Dry Bulb Air Temperatures: $\pm 0.2^{\circ}\text{C}$ ($\pm 0.4^{\circ}\text{F}$)
 - .2 Ambient Dew Point Air Temperatures: $\pm 1.5^{\circ}\text{C}$ ($\pm 2.7^{\circ}\text{F}$)
 - .3 Zone Air Temperatures: $\pm 0.3^{\circ}\text{C}$ ($\pm 0.5^{\circ}\text{F}$)
 - .4 Air Duct Static Pressures: $\pm 25\text{-Pa}$ ($\pm 0.1\text{-inWC}$)
 - .5 Liquid Temperatures: $\pm 0.5^{\circ}\text{C}$ ($\pm 0.9^{\circ}\text{F}$)
 - .6 Air Duct Temperatures: $\pm 0.5^{\circ}\text{C}$ ($\pm 0.9^{\circ}\text{F}$)
 - .7 Air Flow Terminal: $\pm 10\text{-\%}$ of reading.
 - .8 Minimize the number of equipment on/off cycles.
 - .9 Maximize the duration of equipment cycles.
 - .10 Eliminate unnecessary staging of equipment.
 - .11 Prevent undershoot and overshoot on modulating equipment and actuator control.
 - .12 Maximize systems and equipment longevity.
 - .13 Control systems and equipment to maximize energy efficiency.
 - .14 Minimize concurrent heating and cooling including for humidification, dehumidification.
 - .15 Automatically handle failed components, including equipment and end devices, by starting backup devices, and taking actions to minimize consequences.
 - .16 Automatically prevent damage from failed components, including equipment and end devices.
 - .17 Minimize occupant discomfort in case of failed components, including equipment and end devices.
 - .18 Maximize occupant comfort.
- .3 Configure controllers to meet requirements of:
 - .1 ASHRAE-62.1
 - .2 ASHRAE-90.1
- .4 Create user adjustable variables used in programming logic, including for setpoints, limits, delays, offsets, scaling factors, and other constants. Minimize the number of such variables where possible.

- .5 Complete necessary tests, trending, debugging, observation, and adjustments required to fine tune, adjust and modify controller configuration and setpoints to meet design intent.
- .6 Indicated equipment operating limits should be considered as starting points or guidelines only. Consult with equipment manufacturer regarding recommended limits and operating constraints. Coordinate water pressure, air pressure, and flow setpoints with TAB and commissioning requirements. Notify Engineer of any conflicts that may arise in meeting design intent.
- .7 Indicated sequences are intended to communicate suggested control strategies, and in no way absolve Contractor of responsibility as outlined in Contract Documents.
- .8 Provide automatic switchover between specified modes of operation without manual user intervention.
- .9 Configure controllers to coordinate with safeties, safety systems, independent controls and interlocks.
- .10 Configure controllers to coordinate and account for responses and interactive effects of existing or affected systems with controls.
- .11 Schedule equipment based on occupancy schedules, outdoor air temperature switch-point, or on demand.
- .12 Document sequences to ASHRAE-G-13, Article 5.3.3., using the operating mode method.
- .13 Summarize sequences, limits and settings, including interfaces to equipment and components.

3.3 EXISTING SEQUENCES

- .1 Duplicate other existing functionality when changing or replacing controllers.
- .2 Coordinate and adjust sequences to account for responses and interactive effects of existing or affected systems.

3.4 COMMON SEQUENCES

- .1 Occupancy Override
 - .1 Occupancy Override allow users to override default schedules and force zone into occupied mode for a user adjustable duration.
 - .2 Start all required equipment in proper sequence, and maintain zone climate at occupied setpoint for the duration of the override.
- .2 Occupant Adjustment
 - .1 Occupant Adjustment allows users to adjust zone temperature setpoints using features of the zone temperature sensor.
 - .2 Provide adjustable maximum and minimum limits to allowable adjustments for each zone.
 - .3 Provide feature to automatically reset adjustments on an adjustable time period per zone. Provide feature to allow operator to disable this reset feature per zone.
- .3 Equalized Run Time
 - .1 Equalize the run time of equipment where possible by rotating the sequence to which staged equipment are enabled unless otherwise indicated.
 - .2 For lead/lag equipment, alternate lead equipment weekly.
 - .3 Schedule switchover during unoccupied periods, where possible.
- .4 Automatic Failover
 - .1 Provide sequences to automatically and gracefully handle failure by starting backup equipment, including equipment, components, end devices.

3.5 MODES OF OPERATION

- .1 Occupied Mode
 - .1 This mode optimizes central equipment and distribution system reset schedules and enable/disable switch-points for occupied loads and zone temperatures.
 - .2 Scheduled based on daily, weekly and annual schedules.
- .2 Unoccupied Mode

- .1 This mode optimizes central equipment and distribution system reset schedules and enable/disable switch-points for unoccupied loads and zone temperatures.
- .2 Scheduled based on daily, weekly and annual schedules.
- .3 Morning Start-up
 - .1 This mode is used to bring the building out of setback to achieve occupied setpoint temperatures.
 - .2 Scheduled based on daily, weekly and annual schedules, and adjusted for optimal start algorithms.
- .4 Optimal Start Mode
 - .1 This mode optimizes start-up of equipment to minimize energy use while ensuring zone temperatures are at setpoint during occupancy.
 - .2 Based on occupancy schedules, adjusted by calculating the minimum amount of time required to run equipment before occupancy to meet occupied space conditions.
 - .3 Time may vary based on outdoor air conditions, a recorded past history of heating and cooling times, and zone temperature feedback.
 - .4 Maintain unoccupied sequences for outdoor airflow requirements.
 - .5 GUI override button.
- .5 Optimal Stop Mode
 - .1 This mode optimizes the early shutdown of equipment to minimize energy use by taking advantage of building thermal mass.
 - .2 Based on occupancy schedules, adjusted by calculating the maximum amount of time possible to disable equipment before vacancy, while meeting occupied space requirements.
 - .3 Time may vary based on outdoor air conditions, a recorded past history of heating and cooling times, and zone temperature feedback.
 - .4 Maintain unoccupied sequences for outdoor airflow requirements.
 - .5 GUI override button.
- .6 Heating Mode
 - .1 This mode is active when the building may require heating, and is used to enable heating equipment.
 - .2 Based on outdoor air temperature, having separate setpoints for both occupied and unoccupied modes.
 - .3 Include a deadband to prevent cycling.
- .7 Cooling Mode
 - .1 This mode is active when the building may require heating, and is used to enable cooling equipment.
 - .2 Based on outdoor air temperature, having separate setpoints for both occupied and unoccupied modes.
 - .3 Include a deadband to prevent cycling.

3.6 ZONE SETPOINTS

- .1 Background and Intent
 - .1 This article describes sequences for determining and adjusting temperature setpoints.
- .2 Zone Temperature Setpoints - Default
 - .1 Occupied
 - .1 Set zone temperature setpoint to 21-°C (69.8-°F)/23-°C (73.4-°F) in Heating Mode/Cooling Mode respectively.
 - .2 Unoccupied
 - .1 Set zone temperature setpoint to 16-°C (60.8-°F)/28-°C (82.4-°F) in Heating Mode/Cooling Mode respectively.

3.7 VARIABLE AIR VOLUME BOXES

- .1 Background and Intent
 - .1 This article includes sequences for variable air volume air terminal boxes.

- .2 The intent is to match existing sequences and modify the air terminal air flow setpoints as indicated.

3.8 VENTILATION - PACKAGED ROOFTOP AIR HANDLER CONTROL- RTU1

- .1 Background and Intent
 - .1 This article includes sequences for packaged rooftop air handling units, RTU1.
 - .2 Each rooftop air handler includes:
 - .1 2 stage electric heating.
 - .2 Variable speed DX cooling.
 - .3 Variable speed supply fan.
 - .4 Variable speed relief fan.
 - .3 The air handler is controlled by a local controller networked to the BAS system.
 - .4 The air handler controller will control the fan speed, heating staging, cooling modulation.
 - .5 The BAS will enable/disable the fan on schedule, provide setpoints and mode control.
 - .6 Each air handler serves:
 - .1 Single variable air volume zone.
- .2 BAS Control
 - .1 Supply Fan Control
 - .1 Enable/Disable supply fan to schedule.
 - .2 Setpoint Control
 - .1 Provide setpoints including supply air temperature setpoint, zone air temperature setpoint.
 - .3 Mode Control
 - .1 Provide unit mode including fan only, heating mode, cooling mode.
- .3 Air Handler Controller Control
 - .1 Supply Fan Speed and Temperature Control
 - .1 In sequence, modulate supply fan speed from maximum (100-%) to minimum (30-%), then increase supply air temperature from 12-°C (53.6-°F) to 25-°C (77-°F), to reduce zone temperature to setpoint.
 - .2 In sequence, modulate supply air temperature from 25-°C (77-°F) to 12-°C (53.6-°F), then modulate supply fan speed from minimum (30-%) to maximum (100-%), to increase zone temperature to setpoint.
 - .2 Relief Fan Speed Control
 - .1 Set relief fan speed from 100-% to 0-% as outdoor air damper varies from 100-% to 0-%.
 - .2 Reset fan speed +/-25-% as zone static pressure rises above/drops below setpoint.
 - .3 Heating Control
 - .1 Staged Heating Control
 - .1 In sequence start heating stages to increase zone temperature to setpoint.
 - .2 In sequence stop heating stages to decrease zone temperature to setpoint.
 - .3 Disable heating when not in heating mode.
 - .4 Coordinate sequences with manufacturers including for interlocks and safeties.
 - .4 Cooling Control
 - .1 Modulating Cooling Control
 - .1 Modulate cooling compressor to maintain zone temperature at setpoint.
 - .2 Disable cooling when not in cooling mode.
 - .5 Outdoor Air Control
 - .1 Set fixed minimum outdoor air position in coordination with TAB contractor.
 - .2 Provide proportional outdoor air position reset coordinated with fan speed.
 - .3 Replace and/or re-configure existing economizer control with fixed outdoor air dry-bulb temperature.
 - .4 Start/stop Economizer Mode when outdoor air temperature drops below 20-°C (68-°F)/rises above 22-°C (71.6-°F).

- .5 When Economizer Mode is active, and outdoor air temperature is greater than supply air temperature setpoint, modulate outdoor air dampers to 100-% open.
- .6 When Economizer Mode is active, and outdoor air temperature is less than supply air temperature setpoint:
 - .1 Disable mechanical cooling.
 - .2 Modulate outdoor air damper to maintain supply air temperature at setpoint.
- .6 Unoccupied Mode
 - .1 Stop all fans.
 - .2 Close outdoor air dampers.
 - .3 Start air handlers on a call for heating (CFH), call for cooling (CFC) or call for occupancy (CFO) request from zone.
- .7 Low Temperature Protection
 - .1 Stop fans when supply air temperature drops below 5-°C (41-°F) for more than 15-min.
- .8 Fire Alarm
 - .1 Stop fans on smoke detection alarm.

3.9 VENTILATION - PACKAGED ROOFTOP AIR HANDLER CONTROL- RTU2

- .1 Background and Intent
 - .1 This article includes sequences for packaged rooftop air handling unit, RTU2
 - .2 Each rooftop air handler includes:
 - .1 Variable speed DX cooling.
 - .2 Variable speed supply fan.
 - .3 There is a separate return fan, RTU-2_RF, that needs to be coordinated with the RTU-2_SF.
 - .4 The air handler is controlled by a local controller networked to the BAS system.
 - .5 The air handler controller will control the fan speed, heating staging, cooling modulation, supply air temperature setpoint.
 - .6 The BAS will enable/disable the fan on schedule, provide setpoints and mode control.
 - .7 The BAS will provide the discharge air pressure setpoint.
 - .8 The BAS will modulate the return fan speed.
 - .9 Each air handler serves:
 - .1 Multiple variable air volume zones.
- .2 BAS Control
 - .1 Supply Fan Control
 - .1 Enable/Disable supply fan to schedule.
 - .2 Setpoint Control
 - .1 Provide setpoints including supply air temperature setpoint, zone air temperature setpoint.
 - .3 Mode Control
 - .1 Provide unit mode including fan only, heating mode, cooling mode.
 - .4 Discharge Air Pressure Control
 - .1 Provide discharge air pressure setpoint to air handler controller based on maximum VAV box damper position.
 - .5 Return Fan Speed Control
 - .1 Modulate return fan speed to coordinate flow/supply fan speed setpoint table obtained during balancing.
 - .2 Reset to maintain return air plenum pressure at setpoint.
- .3 Air Handler Control
 - .1 Supply Fan Speed Pressure Control
 - .1 Modulate supply fan speed to maintain duct static pressure at setpoint.
 - .2 Supply Air Temperature Setpoint
 - .1 Set supply air temperature setpoint using an outdoor air temperature reset schedule.

- .3 Cooling Control
 - .1 Modulating Cooling Control
 - .1 Modulate cooling compressor to maintain zone temperature at setpoint.
 - .2 Disable cooling when not in cooling mode.
- .4 Outdoor Air Control
 - .1 Provide proportional outdoor air damper reset.
 - .2 Set fixed minimum outdoor air position in coordination with TAB contractor.
 - .3 Replace and/or re-configure existing economizer control with fixed outdoor air dry-bulb temperature.
 - .4 Start/stop Economizer Mode when outdoor air temperature drops below 20-°C (68-°F)/rises above 22-°C (71.6-°F).
 - .5 When Economizer Mode is active, and outdoor air temperature is greater than supply air temperature setpoint, modulate outdoor air dampers to 100-% open.
 - .6 When Economizer Mode is active, and outdoor air temperature is less than supply air temperature setpoint:
 - .1 Disable mechanical cooling.
 - .2 Modulate outdoor air damper to maintain supply air temperature at setpoint.
- .5 Unoccupied Mode
 - .1 Stop all fans.
 - .2 Close outdoor air dampers.
 - .3 Start air handlers on a call for heating (CFH), call for cooling (CFC) or call for occupancy (CFO) request from zone.
- .6 Optimal Start
 - .1 Heating Mode
 - .1 Close outdoor air dampers.
 - .2 Set supply air temperature setpoint to 30-°C (86-°F).
 - .2 Cooling Mode
 - .1 When Economizer Mode is enabled, modulate dampers to maintain supply air temperature at setpoint.
 - .2 When Economizer Mode is disabled, close outdoor air dampers.
 - .3 Set supply air temperature setpoint to 12-°C (53.6-°F).
- .7 Low Temperature Protection
 - .1 Stop fans when supply air temperature drops below 5-°C (41-°F) for more than 15-min.
- .8 Fire Alarm
 - .1 Stop fans on fire alarm.
 - .2 Stop fans on smoke detection alarm.

3.10 HEATING BOILER PLANT CONTROL

- .1 Background and Intent
 - .1 The heating plant includes:
 - .1 1 electric 5 stage boiler.
 - .2 1 heating loop pump.
 - .2 BAS shall enable and disable heating plant.
 - .3 BAS shall control staging of boilers.
 - .4 BAS shall control building heating pump
 - .5 Heating plant serves reheat loops that may operate year round.
- .2 Variables and Calculations
 - .1 Toa: Measured outdoor air temperature.
- .3 Heating Plant Enable/Disable (Winter Mode)
 - .1 Enable Winter Mode when Toa falls below 10-°C (50-°F).
 - .2 Disable Winter Mode when Toa rises above 12-°C (54-°F).
- .4 Heating Boiler Loop Temperature Control

- .1 Enable/disable boiler stages to maintain heating boiler temperature setpoint to building heating loop supply water temperature setpoint plus 10-°C (18-°F).
- .5 Heating Loop Pump Control
 - .1 Start pump when Toa falls below 10-°C (50-°F).
 - .2 Disable pump when Toa rises above 12-°C (54-°F).

3.11 EXHAUST FANS

- .1 Exhaust Fan EF7
 - .1 Start/stop fan to schedule.

3.12 ALARMING

- .1 Alarming to be assigned priorities as follows:
 - .1 Priority 1 alarms are reserved for “life and death safety” situations.
 - .2 Priority 2 alarms are reserved for “building damage” situations such as sump levels, etc.
 - .3 Priority 3-5 alarms are dependent on system by system parameters.
- .2 Control system operators with access level 3 or higher (based on system having 6 or more levels of access) will be able to acknowledge alarms.
- .3 Priority 2 Alarms
 - .1 Heating Boiler Failure Alarm: When all heating boilers fail for more than 60-min, and outdoor air temperature is less than 0-°C (32-°F).
 - .2 Zone Freeze Alarm: When any zone drops below 5-°C (41-°F) for more than 30-min.
 - .3 Air Handler Freeze Alarm: When mixed air temperature falls below 5°C (41-°F) for more that 5-min.
 - .4 Reheat Loop Freeze Alarm: When reheat loop temperature drops below 5-°C (41-°F) for more than 5-min.
- .4 Priority 3 Alarms
 - .1 Variable Frequency Drive Alarms: When VFDs send failure alarms.
 - .2 Pump Failure Alarm: When a pump fails.
 - .3 Failure Alarm: When components fail to achieve commanded status for more than 2-min.
 - .4 Cold Air Temperature: When mixed air temperature is less than 3-°C (37.4-°F) or more than 30-°C (86-°F) for more than 5-min. Alarm will clear when temperature has returned more than 0.5-°C (0.9-°F) into non alarm state for more than 1-min.
 - .5 Hot Water Temperature: When hot water temperature is more than 2°-C (3.6-°F) from set point for more than 15-min after pump has been operating for more than 20-min. Alarm will clear when temperature has returned more than 0.5-°C (0.9-°F) into non alarm state for more than 1-min.
 - .6 Differential Pressure Alarm: When differential pressure is greater than 25-% higher than setpoint for more than 5-min.
- .5 Priority 4 Alarms
 - .1 Hot/Cold Room Alarm: When room temperature is greater than 26-°C (78-°F) or less than 20-°C (68-°F) for more than 15-min during 'occupied' mode. Alarm will clear when temperature has returned more than 0.5-°C (0.9-°F) into non alarm state for more than 1-min.
 - .2 Other Temperatures Too Cold or Too Hot: When other temperature not specifically listed above are off setpoints by more than 10-°C (50-°F) for more than 20-min.
- .6 Priority 5 Alarms
 - .1 Filter Pressure Alarm: When filter pressure differential is greater than 250-Pa (1-inWC) or less than 25-Pa (0.1inWC) for more than 15-min during when main supply fan is operating. Alarm will clear when pressure has returned more than 10-Pa (0.07-inWC) into non alarm state for more than 1-min.
 - .2 Supply Air Temperature Alarm: When supply air temperature is more than 2-°C (3.6-°F) from set point for more than 15-min after main fan has been operating for more than 60-min. Alarm will clear when temperature has returned more than 0.5-°C (3.6-°F) into non alarm state for more than 1-min.

3.13 ADJUSTING

- .1 Adjust configuration as required including sequences.
- .2 To Section 25 50 00 Building Control Systems.

3.14 CLOSEOUT ACTIVITIES

- .1 To Section 25 50 00 Building Control Systems.

END OF SECTION 25 90 00

SECTION 26 00 00 ELECTRICAL DISTRIBUTION

PART 1 GENERAL

1.1 SECTION INCLUDES

- .1 Disconnects, breakers, over-current protection, motor starters, motors, variable frequency drives.

1.2 REFERENCED DOCUMENTS

- .1 ASHRAE-90.1: ANSI/ASHRAE/IES-90.1-2016 Energy Standard for Buildings Except Low-Rise Residential, including User's Manual.
- .2 CSA-C22.1: CSA-C22.1-15 Canadian Electrical Code, Part 1, Safety Standard for Electrical Installations, including Handbook (23rd Edition).
- .3 CSA-C22.2: CSA-C22.2 Canadian Electrical Code, Part 2.
- .4 CSA-O80: CSA-O80-Series-15 Wood Preservation.
- .5 ESA-OESC: ESA Ontario Electrical Safety Code, 2015 (26th Edition).
- .6 NEMA-250: NEMA-250-2014 Enclosures for Electrical Equipment (1000 Volts Maximum).
- .7 NEMA-MG-1: NEMA-MG-1-2014 Motors and Generators.
- .8 ULC-S102: CAN/ULC-S102-10 Surface Burning Characteristics of Building Materials and Assemblies.

1.3 DEFINITIONS

- .1 As defined by ESA-OESC and CSA-C22.1, unless otherwise defined.

1.4 SUBMITTALS FOR ACTION

- .1 Product Data
 - .1 Manufacturers' product literature, specifications, and datasheets. Include product characteristics, performance criteria, options, and limitations.
- .2 Shop Drawings
 - .1 Layout and Interference Plans: Isometric sketches indicating clearances, interferences, and relocation of interfering services, components, objects, and structures.
 - .2 Interlocks: Schematic and wiring diagrams detailing electrical interlocks.
 - .3 Disconnecting Means: Schematic and wiring diagrams detailing methods of disconnecting means.
 - .4 Mounting: Submit layout drawings for equipment mounting, including splitters, starters, disconnects, VFDs. Detail mounting methods, including pads, stands, backing boards.
 - .5 Suspension systems for all suspended equipment. Indicate the following:
 - .1 Location of suspension.
 - .2 Maximum load at each of the suspension points.
 - .3 Size of suspension rods or members.
 - .4 Details of supplementary structural steel framing members.
 - .6 VFD documentation including:
 - .1 List of VFD configuration settings.
- .3 Samples

1.5 SUBMITTALS FOR INFORMATION

- .1 Certificates
 - .1 Letter from supplier of refurbished over-current devices, confirming extent of refurbishment, test results, and certification of suitability for intended use.
 - .2 Letter from a qualified factory-trained manufacturer's representative certifying equipment has been installed, adjusted and tested in accordance with the manufacturer's recommendations.
 - .3 Seismic certification and equipment anchorage details.
 - .4 Certified production test results.
- .2 Delegated Professional Design Submittals
- .3 Manufacturer Information

- .1 Operating and Maintenance Manuals
- .2 Installation Instructions
- .4 Source Quality Control Submittals
- .5 Test and Evaluation Reports
 - .1 Load Balance Report: Report detailing line to line, and line to neutral currents, voltage, and power factor, before and after adjustments.
 - .2 Motor Starter Report: Report detailing motor inrush currents, full load current, and overload setting.
- .6 Qualification Statements
 - .1 Electrical: Proof of licences for company and personnel.
- .7 Documentation
 - .1 Single line power diagram.

1.6 QUALITY ASSURANCE

- .1 Regulatory Requirements
- .2 Qualifications
 - .1 Electrical: Company and personnel to be licensed electricians.
 - .2 Professional Engineering
 - .1 Company and personnel licensed to practice Professional Engineering by PEO.
 - .2 Subject to approval.
- .3 Preconstruction Testing
- .4 Storage and Handling Requirements
- .5 Packaging Waste Management

PART 2 PRODUCTS

2.1 COMMON PRODUCT REQUIREMENTS

- .1 Designed, manufactured, tested and certified in accordance with the latest applicable standards including ANSI, CSA, NEMA, UL and ULC.
- .2 The precise type, rating, quantity and location of electrical products depend, in part, on routing and installation choices made by Contractor.
 - .1 Provide electrical products meeting relevant standards, including CSA-C22.2 and NEMA.
- .3 Match fault current ratings equal to that of upstream over-current protection.
- .4 Provide electrical products rated to suit environment.

2.2 EQUIPMENT MOUNTING

- .1 Provide mounting as required including pads, stands, backing boards, frames, supports.

2.3 DISCONNECTS

- .1 Provide as indicated.
- .2 Manufacturers
 - .1 Eaton Corporation, Cutler-Hammer
 - .2 Schneider Electric
 - .3 Siemens Canada Limited
- .3 Type
 - .1 Fused or unfused as required.
 - .2 Industrial heavy duty, quick-make, quick-break, arc quenching.
 - .3 Lockout rings for "ON" and "OFF" position.
 - .4 Ratings: Horsepower rated to twice the disconnect load unless otherwise indicated.

2.4 MOTORS - INDUCTION - 1-HP AND LARGER

- .1 Provide as indicated.
- .2 Manufacturers
 - .1 Baldor Electric Company
 - .2 Leeson Electric
 - .3 Weg Electric Corp.

- .3 Features
 - .1 Motor Enclosure
 - .1 Provide as required for environment.
 - .2 For replacement motors with existing enclosures rated to exceed environment, match existing.
 - .2 Bearings: Sealed
 - .3 Vertical Oriented Motors: Lock Bearing Construction
 - .4 Thermal Protection: Use Automatic Thermal Overloads for motors less than 1-hp, Manual Thermostats for larger motors.
 - .5 Thermistors: Provide thermistors in windings for motors greater than or equal to 40-hp.
 - .6 Condensation Protection: For motors at risk of condensation, provide integral strip heaters and paint
 - .7 Frame
 - .1 Provide as required.
 - .2 Match existing frame where applicable.
 - .3 Provide frame conversion kit as required.
 - .8 Coupling and Shaft
 - .1 Provide as required.
 - .2 Match existing coupling and shaft where applicable.
 - .3 Provide conversion kit and custom modify shaft as required.
- .4 Type
 - .1 Inverter Ready and General Purpose
 - .1 Application: For variable frequency drive and non-variable frequency drive applications.
 - .2 Features
 - .1 Insulation: Minimum Class F.
 - .2 Service Factor: Minimum 1.15.
 - .3 Performance
 - .1 Turndown Ratio: Minimum 20:1 rated for variable torque applications.
 - .2 Windings: To NEMA-MG-1, Part 31.4.4.2. Capable of withstanding 1,860-V single amplitude zero to peak line to line voltage spikes when subjected to a minimum 0.1- μ s rise time.
 - .4 Options: Provide the following:
 - .1 Motor shaft grounding ring.
 - .5 Performance
 - .1 Speed: 1800-rpm unless otherwise indicated.
 - .2 Except as otherwise permitted, select motors to operate at or below nameplate shaft horsepower at all load operating conditions including run-out.
 - .3 Efficiency: To greater of the following:
 - .1 ASHRAE-90.1 minimum nominal full load efficiency for motor type and purpose.
 - .2 ASHRAE-90.1 minimum average full load efficiency for motor type.
 - .3 NEMA-MG-1 premium efficiency.

2.5 MOTORS - INDUCTION - SMALLER THAN 1-HP

- .1 Provide as indicated.
- .2 Match requirements of larger motors to this Section, except as follows.
- .3 Features
 - .1 Service Factor: Minimum 1.15.
- .4 Performance
 - .1 Speed: As indicated, otherwise as follows where not indicated.
 - .1 Pumps: Maximum 3600-rpm for motors less than 1/2-hp.
 - .2 Other: Maximum 1800-rpm

- .2 Efficiency
 - .1 To ASHRAE-90.1, Table 10.8-4 and Table 10.8-5, otherwise to ASHRAE-90.1, Article 6.5.3.5 for fans including exceptions.

2.6 MOTORS - ELECTRONICALLY COMMUTATED

- .1 Provide as indicated.
- .2 Manufacturers
 - .1 Greenheck Fan Corp., Vari-Green Series
- .3 Motor Enclosure
 - .1 Provide as required for environment.
- .4 Features
 - .1 Permanently lubricated heavy duty bearings.
 - .2 Prewired to specific voltage and phase.
 - .3 Internal controller shall convert AC power to DC power.
 - .4 5:1 turn down.
- .5 Options
 - .1 POT: Potentiometer control.
 - .2 REM: 0-10-VDC control.
 - .3 DUAL: 0-10-VDC and potentiometer control.
- .6 Performance
 - .1 Efficiency: Minimum 80-% at all speeds.
 - .2 Speed: As indicated.
- .7 Unacceptable:
 - .1 AC induction motors including:
 - .1 Shaded Pole
 - .2 Permanent Split Capacity
 - .3 Split Phase
 - .4 Capacitor Start

2.7 MOTOR STARTERS

- .1 Provide as required.
- .2 Manufacturers
 - .1 Motor starters installed in motor control centres:
 - .1 Same manufacturer and series as the motor control center.
 - .2 Motor starters not installed in motor control centres:
 - .1 Eaton Corporation, Cutler-Hammer
 - .2 Schneider Electric
 - .3 Siemens Canada Limited
- .3 Type: AMS - Automatic Motor Starter
 - .1 Features
 - .1 Solid state overload relays.
 - .1 Self-powered.
 - .2 Phase loss protection.
 - .3 Visible trip indication.
 - .4 Test trip feature.
 - .5 Ambient temperature compensated.
 - .2 Indicating lights for RUN and FAULT.
 - .3 Selector switch for HAND-OFF-AUTO.
 - .4 Fused control power transformer.
 - .5 Integral disconnect switch.
 - .2 Size: As required.
- .4 Type: MMS - Manual Motor Starter
 - .1 Features
 - .1 Bi-metallic overload relays.
 - .1 Single phase sensitivity.

- .2 Visible trip indication.
- .3 Test trip feature.
- .2 Indicating lights for RUN and FAULT.
- .3 Integral disconnect switch.
- .2 Size: As required.

2.8 OVER-CURRENT PROTECTION

- .1 Provide as required.
- .2 Manufacturers: Match manufacturer, features, type, quality, and interrupting current rating of existing over-current protection where possible. Otherwise:
 - .1 Eaton Corporation, Cutler-Hammer
 - .2 Schneider Electric
 - .3 Siemens Canada Limited
- .3 Type
 - .1 As required to maintain selective coordination.
- .4 Options: Provide the following:
 - .1 Circuit Breaker Adjustable Trip Unit
 - .1 Provide on circuit breakers 300-A or larger. Provide on circuit breakers 300-A or less as required to maintain selective coordination
 - .2 Manufacturers: Eaton Corporation, Cutler-Hammer, Digitrip RMS510
 - .3 Features: Long delay, short delay, instantaneous and ground fault trip settings.
- .5 Ratings

2.9 OVER-CURRENT TRIP RELAYS

- .1 Provide as required.
- .2 Manufacturers
 - .1 Compatible with existing trip unit.
- .3 Type
 - .1 Compatible with existing trip unit where possible.
 - .2 Adjustable delay and pickup for long, short, instantaneous overload settings.
 - .3 Adjustable delay and pickup for ground fault.
- .4 Size: Verify existing standby loads under worst case conditions. Select compatible over-current trip relay.

2.10 OTHER ACCESSORY PRODUCTS

- .1 Receptacles
 - .1 Provide at the following locations:
 - .1 As required.
 - .2 Where mounts are ready for receptacles.
 - .2 Provide types as required.
- .2 Receptacle Weatherproof Covers
 - .1 Provide as required.
 - .2 Locations: Damp, wet, outdoor. Not exposed to public access.
 - .1 Manufacturers
 - .1 Hubbell Electrical Systems, Hubbell Wiring Device-Kellems
 - .2 Leviton Manufacturing Co., Inc.
 - .2 Materials
 - .1 Cover: Powder coated cast zinc.
 - .2 Hinges: Stainless steel.
 - .3 Gasket: Closed-cell foam.
 - .3 Selection: Suitable for horizontal and vertical mounting as required.
 - .4 Features
 - .1 Weatherproof "while in use".
 - .2 Labelled "extra duty".
 - .3 Latching extra deep cover with large cord openings.

- .4 Mounting drill points in 4 corners for mounting receptacle plate.
- .5 Padlock hole 6.4-mm (0.25-in) diameter.
- .6 Pre-mounted heavy duty gasket.
- .5 Other Ratings
 - .1 Ingress Protection
 - .1 Minimum NEMA Type 3R rated to NEMA-250.
 - .2 Maintain ratings while in use.
 - .6 Certifications, Listings and Registrations
 - .1 CSA certified.
 - .2 UL listed.

2.11 STANDS

- .1 Provide as required.
- .2 Type: Prefabricated metal channel, weldless connections.
- .3 Manufacturer: Atkore International, Inc., Unistrut Metal Framing
- .4 Size: Minimum 19-mm (3/4-in) thick.
- .5 Finish: Painted including for corrosion protection.

2.12 BACKING BOARD

- .1 Provide as required.
- .2 Materials: Pressure impregnated treated plywood with fire-retardant chemicals to CSA-O80.
- .3 Performance
 - .1 Flame-Spread: Maximum 25 tested to ULC-S102.
- .4 Size: 19-mm (3/4-in) thick.
- .5 Finish: Painted to match panels and equipment.

2.13 STANDOFFS

- .1 Provide as required.
- .2 Type: Prefabricated metal channel, weldless connections.
- .3 Manufacturer: Atkore International, Inc., Unistrut Metal Framing
- .4 Size: Minimum 19-mm (3/4-in) thick.
- .5 Finish: Painted including for corrosion protection.

2.14 SOURCE QUALITY CONTROL

- .1 Complete factory tests in accordance with NEMA, UL and ULC standards.
- .2 Complete all laboratory and manufacturer testing required to refurbish existing over-current protection devices, and obtain required re-certification.
- .3 Submit documentation and certified copies of test results.

PART 3 EXECUTION

3.1 EXAMINATION

- .1 Photograph, document and submit descriptions of existing deficiencies in affected systems, equipment, services and surrounding areas prior to commencing Work.
- .2 Confirm the condition, installation, location, quantity and type of applicable equipment.
- .3 Complete x-ray scans, consultation, and other investigative work as required to verify structural member construction, verify suitable locations, and ensure drilling and coring through structural members will not affect integrity.
- .4 Investigate affected fire separations for existing improperly sealed or defective fire stopping.
- .5 Verify circuits on affected panels.

3.2 EXISTING MOTOR CONTROL CENTERS AND PANELBOARDS

- .1 Pre-installation Measurement
 - .1 Energize all loads to simulate full load conditions.
 - .2 Measure line to line, and line to neutral currents, voltage, and power factor before installation.
 - .3 Report on panels that may become loaded more than 80-%.

3.3 COMMON EXECUTION REQUIREMENTS

- .1 Provide services, including mechanical, to equipment as required.
- .2 Provide equipment with identification as indicated. Nameplates to match quality and style of existing.
- .3 Replace services around equipment to fit equipment and to suit equipment requirements, including piping, ductwork, venting, wiring.
- .4 Install products in locations providing appropriate ambient conditions for its operation, and allowing for adequate ventilation.
- .5 Provide clearances around systems, equipment and components for inspection, servicing and maintenance and as required. Minimum clearance of 300-mm (1-ft).
- .6 Provide clearances around products to prevent interference with adjacent systems, equipment and components.
- .7 Noise and Vibration Control
 - .1 Install vibration control hardware in accordance with manufacturer's instructions (and supervision where required) and only by workmen experienced in the installation of such systems.
 - .2 Provide anti-vibration mounts or anti-vibration couplings when connecting wiring, conduit, or enclosures to mechanical equipment.
 - .3 Replace isolation pads, and modify supports as required to mitigate vibration and noise to Owner's satisfaction.
- .8 Repair/Restoration
 - .1 Use new original manufacturer parts for replacement where possible.
 - .2 Obtain all registrations or certifications required for original parts sent to a third party for refurbishment. Submit parts re-certification as required.
 - .3 Obtain all certifications and testing required when modifying existing equipment.
- .9 The precise type, rating, quantity and location of electrical products depend, in part, on routing and installation choices made by Contractor.
 - .1 Verify specified cable size, raceway size, insulation type, and over-current protection.
 - .2 Adjust sizing and selection of products as required.
- .10 Provide equipment safeties and interlocks as required.
- .11 Disconnecting Means: Provide disconnecting means as required, including disconnects.
- .12 Power Surges: Protect upstream electrical equipment from power line, voltage transients and damage during construction power surges.
- .13 Should complications arise due to incorrect selection, Contractor shall be responsible for costs incurred in replacing damaged components.
- .14 Manufacturer Services
 - .1 Supervision: Manufacturer to supervise field assembly of equipment to ensure warranty and performance provisions are met.
 - .2 Start-up: Manufacturer to approve installation, to supervise start-up, and to instruct Owner, unless otherwise indicated.
 - .3 Adjusting: Adjust for optimal performance, under manufacturer supervision.

3.4 EQUIPMENT MOUNTING

- .1 Intent: Contractor responsibility as requirements depend in part on final selection and installation location.
- .2 Design mounting as required where not indicated, including pads, stands, backing boards, frames, supports.
- .3 Support equipment such that no loads are transmitted to services including piping, ductwork, venting, wiring.
- .4 Provide concrete housekeeping pads for base-mounted equipment.
 - .1 Size: Minimum 100-mm (4-in) high, larger in width and depth by 75-mm (3-in).
- .5 Provide stands for equipment that can be wall mounted but are not located on walls unless otherwise indicated. Anchor bolt to surfaces.

- .6 Provide backing boards with standoffs for wall mounted equipment unless otherwise indicated. Anchor bolt to surfaces.
- .7 Provide standoffs for wall mounted equipment as indicated, or in environments and locations not suitable for backing boards. Anchor bolt to surfaces. Use of standoffs only instead of backing boards as approved by Engineer.
- .8 Performance: Design equipment mounting:
 - .1 To make equipment level.
 - .2 To protect equipment from water damage.
 - .3 To withstand seismic events with seismic restraint as required.
 - .4 To minimize noise and vibration transmitted to services and building structure.
 - .5 To withstand concentrated loads of 2-kN (450-lbf) applied at any point in any direction.

3.5 DISCONNECTS

- .1 Install as required.

3.6 MOTORS

- .1 Install as required.
- .2 Wire thermistors to VFDs.
- .3 Measure inrush and full load current upon start-up of motors.
- .4 Adjust overload settings or replace overloads as required.
- .5 Replace upstream over-current protection as required to prevent nuisance tripping on motor start-up and operation.

3.7 MOTOR STARTERS

- .1 Install as required.
- .2 Adjust overload settings as required.
- .3 Modify existing as required, including:
 - .1 Provide manual override (HAND-OFF-AUTO) functionality.
 - .2 Remove and blank off spaces from abandoned components including HAND-OFF-AUTO controls when new motor starters including VFDs are installed downstream.

3.8 OVER-CURRENT PROTECTION

- .1 Install as required.
- .2 Coordinate over-current protection with upstream and downstream over-current devices. Set adjustable settings for proper coordination.

3.9 OVER-CURRENT TRIP RELAYS

- .1 Install as required.
- .2 Verify existing standby loads under worst case conditions before selecting and installing products.

3.10 OTHER ACCESSORY PRODUCTS

- .1 Receptacles
 - .1 Install as required.
- .2 Receptacle Weatherproof Covers
 - .1 Install as required.
 - .2 Finish: Paint as follows:
 - .1 As required by Owner, including colour and gloss or matte finish.
 - .2 To match surrounding surfaces, including colour and gloss or matte finish.

3.11 LABELLING

- .1 Nameplates: Affix manufacturer's nameplates to equipment in a readily visible location.
- .2 Identification: Provide lamacoid nameplates for identification on each enclosure, panel, or field equipment, including existing.
 - .1 Construction: Laminated plastic with a different coloured core and engraved lettering to clearly show lettering with style as follows, unless otherwise specified:

- .1 Style: Capital letters, minimum 12-mm (1/2-in) high, equal character spacing, centered (not justified).
- .2 Colours: Colours of letters and background may change for each type of equipment or component. Provide colours to Owner requirements, otherwise provide white letters and black background.
- .2 Nameplate Content
 - .1 Equipment: Name tag of equipment.
 - .2 Panels, switchboards, transformers, or other distribution equipment: Name tag of equipment and location of electrical power feed(s).
- .3 Warning: Provide warning labels as required, including:
 - .1 Warning of automatic control.
 - .2 Warning of enclosures containing multiple voltages or multiple voltage sources.
- .4 Directories: Prepare updated written circuit directory on affected panels. Affix updated circuit directory to panel door, enclosed in a plastic protective sleeve.
- .5 Ceiling Labelling
 - .1 Provide coloured labels on ceiling surfaces to indicate equipment and components including the following. Colours indicated are indicative of requirements and Owner may change for each type of equipment or component.
 - .2 Provide labels as acceptable to Owner, including label type, material, size and colour. Owner may require lamacoids, adhesive labels with text, adhesive labels with no text.
 - .3 Mark each label as acceptable to Owner, including equipment label, type, power circuit.

3.12 START-UP

- .1 Motor Control Centers and Panelboards
 - .1 After installation of new circuits, energize all loads to simulate full load conditions.
 - .2 Measure line to line, and line to neutral currents, voltage, and power factor.
- .2 Provide services of qualified factory-trained manufacturer's representative to assist with installation and start-up.
 - .1 Submit manufacturer's start-up report, and written certification that the equipment has been installed, adjusted and tested in accordance with the manufacturer's recommendations.

3.13 ADJUSTING

- .1 Adjusting: Adjust settings as required before Total Performance and throughout Warranty Period to address performance issues, including safeties, operating limits, noise, vibration, efficiency, equipment longevity.

3.14 CLEANING

- .1 Cleaning: Clean and vacuum enclosures and junction boxes after completion of work.

3.15 CLOSEOUT ACTIVITIES

- .1 Documentation
 - .1 Provide new single line power diagram for affected areas, including new systems and existing systems. Verify existing systems. Coordinate diagram style and notations with existing and new diagrams. Provide appropriately sized frames with glass cover for each affected area. Match existing single line power diagram frames unless otherwise approved by Owner. Mount single line power diagram in frames on walls of affected areas in locations approved by Owner.

END OF SECTION 26 00 00

SECTION 26 05 00 WIRING AND CABLES

PART 1 GENERAL

1.1 SECTION INCLUDES

- .1 Wiring and cables for power, communication networks, control, raceway.

1.2 REFERENCED DOCUMENTS

- .1 ASHRAE-90.1: ANSI/ASHRAE/IES-90.1-2016 Energy Standard for Buildings Except Low-Rise Residential, including User's Manual.
- .2 CSA-C22.1: CSA-C22.1-15 Canadian Electrical Code, Part 1, Safety Standard for Electrical Installations, including Handbook (23rd Edition).
- .3 CSA-C22.2: CSA-C22.2 Canadian Electrical Code, Part 2.
- .4 CSA-C22.2-0.3: CSA-C22.2 No. 0.3-09 (R2014) Test Methods for Electrical Wires and Cables.
- .5 CSA-C22.2-45.2: CSA-C22.2 No. 45.2-08 (R2013) Electrical Rigid Metal Conduit - Aluminum, Red Brass, and Stainless Steel.
- .6 CSA-C22.2-56: CSA-C22.2 No. 56-13 Flexible Metal Conduit and Liquid-Tight Flexible Metal Conduit.
- .7 CSA-C22.2-83: CSA-C22.2 No. 83-M1985 (R2013) Electrical Metallic Tubing.
- .8 CSA-C22.2-83.1: CSA-C22.2 No. 83.1-07 (R2012) Electrical Metallic Tubing - Steel.
- .9 CSA-C22.2-211.2: CSA-C22.2 No. 211.2-06 (R2011) Rigid PVC (Unplasticized) Conduit.
- .10 CSA-C22.2-227.1: CSA-C22.2 No. 227.1-06 (R2016) Electrical Nonmetallic Tubing.
- .11 CSA-C22.2-262: CAN/CSA-C22.2 No. 262-16 Optical Fiber Cable and Communication Cable Raceway Systems.
- .12 CSA-C22.2-2420: CSA-C22.2 No. 2420-09 (R2014) Belowground Reinforced Thermosetting Resin Conduit (RTRC) and Fittings.
- .13 CSA-C22.2-2515: CSA-C22.2 No. 2515-09 (R2014) Aboveground Reinforced Thermosetting Resin Conduit (RTRC) and Fittings.
- .14 CSA-C22.2-2515.1: CSA-C22.2 No. 2515.1-13 Supplemental Requirements for Extra Heavy Wall (XW) Reinforced Thermosetting Resin Conduit (RTRC) and Fittings.
- .15 ESA-OESC: ESA Ontario Electrical Safety Code, 2015 (26th Edition).
- .16 NECA-1: ANSI/NECA-1-2015 Standard for Good Workmanship in Electrical Construction.
- .17 TIA-568.2: ANSI/TIA-568-C.2 Balanced Twisted-Pair Telecommunication Cabling and Components Standard (Edition C, 2012).
- .18 TIA-568.3: ANSI/TIA-568.3-D Optical Fiber Cabling and Components Standard (Edition D, 2016).
- .19 ULC-S115: CAN/ULC-S115-11 (R2016) Standard Method of Fire Tests of Firestop Systems.
- .20 ULC-S139: CAN/ULC-S139-12 Standard Method of Fire Test for Evaluation of Integrity of Electrical Cables.

1.3 DEFINITIONS

- .1 As defined by ESA-OESC and CSA-C22.1, unless otherwise defined.

1.4 SUBMITTALS FOR ACTION

- .1 Product Data
 - .1 Manufacturers' product literature, specifications, and datasheets. Include product characteristics, performance criteria, options, and limitations.
- .2 Shop Drawings
 - .1 Layout and Interference Plans: Isometric sketches indicating clearances, interferences, and relocation of interfering services, components, objects, and structures.
 - .2 Single Line: Single line electrical schematic showing:
 - .1 Cable sizes and quantities.
 - .2 Conductor types and quantities per cable.

- .3 Insulation types and temperature ratings per conductor and cable.
- .4 Raceway types, dimensions.
- .5 Maximum current capacity.
- .6 Overcurrent protection details.
- .7 Other code requirements.
- .8 Other regulatory requirements.
- .3 Interlocks: Schematic and wiring diagrams detailing electrical interlocks.
- .4 Disconnecting Means: Schematic and wiring diagrams detailing methods of disconnecting means.
- .5 Fire Separations: Location of penetrations through fire separations and other assemblies.
- .6 Fire Stopping and Smoke Seals
 - .1 Locations and types marked on plan drawing.
 - .2 ULC assembly number certification.
 - .3 Required temperature rise and flame rating.
 - .4 Hose stream rating where applicable.
 - .5 Materials of fire stopping and smoke seals, primers, reinforcements, damming materials, reinforcements, and anchorages/fastenings.
 - .6 Assembly and penetration type and required ratings, adjacent materials.
 - .7 Openings size, thickness, dimensions.
 - .8 Proposed installation methods.
 - .9 Summaries of similar types of penetrations, assembly type and construction, service penetrating assembly, adjacent materials, fire stopping and smoke seal type, ratings, other work required.
 - .10 Copies of ULC certifications for proposed systems and designs for specific devices and materials.
 - .11 Image of sample tag.

1.5 SUBMITTALS FOR INFORMATION

- .1 Certificates
 - .1 Production test results.
 - .2 Seismic certification and equipment anchorage details.
 - .3 Letter from fire stopping and smoke seals installer certifying that fire stopping and smoke seals have been installed in accordance with regulatory requirements and Contract Documents.
- .2 Manufacturer Information
 - .1 Installation Instructions
- .3 Test and Evaluation Reports
 - .1 Load Balance Report: Report detailing line to line, and line to neutral currents, voltage, and power factor, before and after adjustments.
- .4 Qualification Statements
 - .1 Electrical Work: Company and personnel to be licensed electricians.

1.6 QUALITY ASSURANCE

- .1 Qualifications
 - .1 Electrical Work: Company and personnel to be licensed electricians.
 - .2 Fire Stopping and Smoke Seals: Company member of FCIA.

PART 2 PRODUCTS

2.1 COMMON PRODUCT REQUIREMENTS

- .1 Designed, manufactured, tested and certified in accordance with the latest applicable standards including ANSI, CSA, NEMA, UL and ULC.
- .2 The precise type, rating, quantity and location of electrical products depend, in part, on routing and installation choices made by Contractor.
 - .1 Provide electrical products meeting relevant CSA-C22.2 standards.

- .3 Match fault current ratings equal to that of upstream over-current protection.
- .4 Provide electrical products rated to suit environment.

2.2 POWER WIRING AND CABLES

- .1 Provide as required.
- .2 Materials
 - .1 Copper for all conductors including integral ground/bonding wires.
 - .2 Stranded for #10-AWG and larger.
- .3 Size: To the larger of:
 - .1 One size larger than required by ESA-OESC.
 - .2 One size larger than equipment MCA.
 - .3 As required by ASHRAE-90.1.
 - .4 #12-AWG.
 - .5 As indicated.
- .4 Ratings
 - .1 Temperature: Minimum 90-°C (200-°F) unless otherwise required.
 - .2 Voltage
 - .1 Minimum 1,000-V for cables between 575-V rated variable frequency drives and motors.
 - .2 Minimum 600-V otherwise.
 - .3 Flame Test Rating
 - .1 FT6 to CSA-C22.2-0.3 as required by local building code, including for plenums, combustible construction.
 - .2 FT4 to CSA-C22.2-0.3 otherwise.
 - .4 Fire Rating: Minimum 2-hour fire rating certified to ULC-S139 where fire rating is indicated.
- .5 Cable Types
 - .1 RW90-XLPE: Chemically cross linked thermosetting polyethylene material with CSA type RW90. Suitable for wet and dry locations.
 - .2 RWU90-XLPE: Chemically cross linked thermosetting polyethylene material with CSA type RWU90. Suitable for underground burial.
 - .3 T90/TWN75: Thermoplastic insulation with CSA type TWH, with nylon jacket. Suitable for wet and dry locations.
 - .4 TECK90: Armoured cable, polyvinyl chloride jackets on the outside and inside of the armour. Suitable for wet and dry locations.
 - .1 Armour: Interlocked aluminum.
 - .2 Conductor Insulation: Chemically cross linked thermosetting polyethylene material with CSA type RW90.
 - .5 ACWU90: Armoured cable, polyvinyl chloride jacket, suitable for wet and dry locations.
 - .1 Armour: Interlocked aluminum.
 - .2 Conductor Insulation: Chemically cross linked thermosetting polyethylene material with CSA type RW90.
 - .6 AC90: Armoured cable, no jacket, CSA type AC90. Suitable for dry locations.
 - .1 Armour: Interlocked aluminum.
 - .7 RA90: Aluminum sheathed cable, CSA type RA90, polyvinyl chloride jacket. Suitable for wet and dry locations.
 - .1 Armour: Continuous aluminum sheath.
 - .2 Conductor Insulation: Chemically cross linked thermosetting polyethylene material with CSA type RW90.
 - .8 FAS: CSA type FAS and applicable UL ratings.

2.3 COMMUNICATION NETWORKS WIRING AND CABLES

- .1 Provide as required.

- .2 Coordinate requirements as required, including for communication network repeaters, gateways, boosters, interfaces, and other equipment, components and accessories.
- .3 Cable Types
 - .1 CAT5, CAT5e, CAT6 - Category #: To TIA-568.2, TIA-568.2, TIA-568.3, multiple shielded twisted pair.
 - .2 STP - Shielded Twisted Pair: #18 AWG, 100-ohm to 130-ohm impedance, capacitance less than 30-pF per foot.
- .4 Ratings
 - .1 Flame Test Rating
 - .1 FT6 to CSA-C22.2-0.3 as required by local building code, including for plenums, combustible construction.
 - .2 FT4 to CSA-C22.2-0.3 otherwise.

2.4 CONTROL WIRING AND CABLES

- .1 Provide as required.
- .2 Coordinate requirements as required, including for signal conditioning and isolation, and other equipment, components and accessories.
- .3 Cable Types
 - .1 CLA1 - Class 1: To TIA-568.2, TIA-568.2, TIA-568.3, shielded twisted pair.
 - .2 STP - Shielded Twisted Pair: #18 AWG, 100-ohm to 130-ohm impedance, capacitance less than 30-pF per foot.
- .4 Size
 - .1 Size control wires to manufacturer's recommendations.
 - .2 Minimum #18-AWG unless otherwise specifically required by manufacturer.
- .5 Materials: Copper.
- .6 Ratings
 - .1 Temperature: Minimum 90-°C (200-°F) unless otherwise required.
 - .2 Flame Test Rating
 - .1 FT6 to CSA-C22.2-0.3 as required by local building code, including for plenums, combustible construction.
 - .2 FT4 to CSA-C22.2-0.3 otherwise.

2.5 RACEWAYS

- .1 Provide as required.
- .2 Size: Minimum 21-mm (3/4-in), even if smaller size may otherwise be permissible.
- .3 Type
 - .1 EMT - Electrical Metallic Tubing: To CSA-C22.2-83.1.
 - .1 Materials: Hot dipped galvanized steel.
 - .2 ENT - Electrical Nonmetallic Tubing: To CSA-C22.2-227.1.
 - .1 Flame Test Rating
 - .1 FT6 to CSA-C22.2-262 and as required by local building code, including for plenums, combustible construction.
 - .2 FT4 to CSA-C22.2-262 otherwise.
 - .3 FMC - Flexible Metal Conduit: To CSA-C22.2-56.
 - .4 FMC-LT - Liquid Tight Flexible Metal Conduit: To CSA-C22.2-56.
 - .5 PVC - Rigid PVC (Unplasticized) Conduit: To CSA-C22.2-211.2.
 - .6 RMC - Rigid Metal Conduit: To CSA-C22.2-45.2.
 - .1 Materials: Aluminum.
 - .7 RTRC-AG - Aboveground Reinforced Thermoset Rigid Conduit, or Fibreglass Conduit: To CSA-C22.2-2515.
 - .8 RTRC-AG-XW - Aboveground Extra Heavy Wall Reinforced Thermoset Rigid Conduit: To CSA-C22.2-2515.1.
 - .9 RTRC-BG - Belowground Reinforced Thermoset Rigid Conduit, or Fibreglass Conduit: To CSA-C22.2-2420.

2.6 SUPPORTS AND HANGERS

- .1 Design of wiring and cables support depends, in part, on routing and installation choices made by Contractor. Design of wiring and cables support is Contractor responsibility.
- .2 Provide as required.
- .3 Materials: Metal, corrosion resistant.
- .4 Unacceptable
 - .1 Wire lashing.
 - .2 Perforated straps.

2.7 ACCESS HATCHES

- .1 Provide access hatches:
 - .1 At concealed electrical components.
 - .2 At equipment and components requiring maintenance, inspections and for convenience purposes.
 - .3 In fixed surfaces including walls, ceilings.
 - .4 At other locations as required.
- .2 Type: Quick opening hardware. Lockable.
- .3 Fasteners
 - .1 General: Provide countersunk holes where fasteners are not concealed.
 - .2 Size: Square with minimum free opening 0.1-m² (1-ft²). Other shapes to be approved by Owner.
- .4 Finish: To match fixed surfaces.

2.8 FIRE STOPPING AND SMOKE SEALS

- .1 Asbestos-free materials and systems capable of maintaining effective barrier against flame, smoke and gases to ULC-S115.
- .2 Manufacturers: 3M Canada Company, Fire Protection Products
- .3 Materials
 - .1 Fire stopping and smoke seal components: Certified by test laboratory to ULC-S115.
 - .2 In assemblies: Systems tested to ULC-S115.
 - .3 In wet environments, waterproof assemblies, or exterior assemblies including foundations and below grade floors: Waterproof, non-hardening.
 - .4 Penetrations requiring vibration control: Elastomeric seal.
 - .5 Damming and backup materials, supports and anchoring devices: To manufacturer's recommendations, and in accordance with tested assembly being installed as acceptable to authorities having jurisdiction.
 - .6 Other locations: As required.
- .4 Performance: Rating: 2-hours, unless otherwise required.

PART 3 EXECUTION

3.1 EXAMINATION

- .1 Photograph, document and submit descriptions of existing deficiencies in the affected wiring, raceway and support systems prior to commencing Work.
- .2 Complete x-ray scans, consultation, and other investigative work as required to verify structural member construction, verify suitable locations, and ensure drilling and coring through structural members will not affect integrity.
- .3 Investigate fire separations and non-fire-resistance rated assemblies in affected areas for existing fire stopping or smoke sealing that is improperly sealed or defective, as well as for penetrations not fire stopped or smoke sealed.
- .4 Verify characteristics of indicated components, including sizes and types, including raceways, wiring and cables, insulation, and over-current protection. Adjust sizing and selection as required.

3.2 PREPARATION

- .1 Demolition and Removal
 - .1 Remove existing unused plenum cable in affected areas.

- .2 Remove existing unused and obsolete services and components including wiring, raceway, and support systems.

3.3 COMMON EXECUTION REQUIREMENTS

- .1 The precise type, rating, quantity and location of electrical products depend, in part, on routing and installation choices made by Contractor.
- .2 Complete Work:
 - .1 To ESA-OESC.
 - .2 To CSA-C22.1.
 - .3 To NECA-1 unless otherwise indicated.
- .3 Locations
 - .1 Install products in locations providing appropriate ambient conditions for its operation, and allowing for adequate ventilation.
 - .2 Install products to allow maintenance access and to prevent interference with adjacent equipment.
 - .3 Install products to facilitate various activities including maintenance and inspection:
 - .1 Provide sufficient additional wiring lengths.
 - .2 Provide wiring quick disconnecting means.
 - .4 Install in a manner to not interfere with normal traffic patterns.
 - .5 Install above 150-mm (6-in) of floor and other similar surfaces, including surface of housekeeping pads and other similar horizontal surfaces.
 - .6 Install above snow drift region, including surface of ground and roof and other similar surfaces, including equipment mounting curbs and flashing.
 - .7 Install and layout to account for extremes of expansion and contraction that system may be subject to.
- .4 Grounding and Bonding: Provide a separate insulated grounding and bonding conductor in raceways containing power circuits, even if such separate conductor may not otherwise be required due to raceway material construction.
- .5 Power Surges: Protect upstream loads and equipment from power line, voltage transients and damage during construction power surges.
- .6 Enclosures
 - .1 Use dedicated enclosures.
 - .2 Document enclosures that contain mixed voltages, and/or circuits operating under separate control.
- .7 Junctions and Splicing: Unless otherwise indicated or required:
 - .1 When modifying or extending existing wiring and cables, maximum 1 junction or splice allowed for each wire and cable, excluding terminations at required equipment, components and accessories.
 - .2 Otherwise, install wiring and cables in continuous lengths, free from junctions and splices, except for terminations at required equipment, components and accessories.

3.4 POWER WIRING AND CABLES

- .1 Install as required.
- .2 Locations: Provide the following.
 - .1 Outdoor, fully exposed to elements:
 - .1 TECK90
 - .2 Outdoor, wet, or damp locations except for underground burial:
 - .1 RW90-XLPE cable in RMC raceway.
 - .3 Service traffic areas, including corridors and hallways and pathways within rooms, subject to mechanical damage from moving objects including forklifts, carts, and vehicles:
 - .1 RW90-XLPE cable in RMC raceway.
 - .4 Service areas, including rooms, exposed:
 - .1 #10-AWG and smaller:
 - .1 RW90-XLPE cable in EMT raceway.

- .2 Service areas, including rooms, #8-AWG and larger:
 - .1 RW90-XLPE cable in EMT raceway.
- .5 Ceiling cavities, non-ducted return air plenums:
 - .1 #12-AWG and smaller:
 - .1 RW90-XLPE cable in EMT raceway.
 - .2 #10-AWG and larger:
 - .1 RW90-XLPE cable in EMT raceway.
- .6 Walls, concealed:
 - .1 RW90-XLPE cable in FMC raceway.
- .7 Concealed chases, service areas, behind other surfaces:
 - .1 RW90-XLPE cable in EMT raceway.
- .3 Terminations to Loads and Equipment: Provide the following superseding requirements.
 - .1 Junction Boxes
 - .1 Provide junction boxes from raceways located not more than 3-m (10-feet) from equipment.
 - .2 Vibration Terminations: Wiring and cables serving vibrating loads and equipment:
 - .1 FMC-LT raceway.
 - .3 Vibration Isolation: Terminations intended for vibration isolation:
 - .1 Provide anti-vibration mounts or anti-vibration couplings at equipment.
 - .2 Minimum length 1-m (40-in).
 - .4 Removable: Wiring and cables serving devices or components that are expected to normally be removed from mounting, regardless of frequency of removal, including for service or inspection:
 - .1 FMC-LT raceway.
- .4 Other
 - .1 For other locations, terminations, and parts served, match to most similar indicated above, with minimum as follows:
 - .1 RW90-XLPE cable in EMT raceway.
 - .2 Specifically Prohibited
 - .1 Exposed wiring and cables.
 - .2 Exposed raceways in non-service areas.
 - .3 Exposed raceways unless specifically indicated above.

3.5 COMMUNICATION NETWORKS WIRING AND CABLES

- .1 To power wiring and cables in this Section, with specific modifications and additional requirements under this Article.
- .2 Communication Network Types: Provide the following:
 - .1 Ethernet:
 - .1 CAT5e or CAT6, installed to TIA-568.2, TIA-568.2, TIA-568.3.
 - .2 RS-232, RS-485, and proprietary MS/TP networks:
 - .1 CAT5e or CAT6, installed to TIA-568.2, TIA-568.2, TIA-568.3.
- .3 Communication Network Types Modified: If controller product manufacturer has specific requirements that are of a lesser quality than as indicated above, submit for review and agreement.
- .4 Raceways Modified: Raceway requirements may be modified, unless otherwise required by regulation, as follows:
 - .1 Raceways are waived for the following:
 - .1 Circuits: Class 2 circuits to ESA-OESC that are less than 30-V.
 - .2 Purpose: Wiring and cables not for the purposes of life safety, including fire.
 - .3 Locations
 - .1 Walls, concealed.
 - .2 Concealed chases, service areas, behind other surfaces.
 - .3 Ceiling cavities, non-ducted return air plenums.

- .5 Components: Provide required additional components including repeaters, gateways, boosters, interfaces, and other equipment and accessories.
- .6 Locations: Minimum 1-m (3.2-ft) separation from power and control wiring.
- .7 Spare Lengths: Provide spare 3-m (10-ft) length at each termination.

3.6 CONTROL WIRING AND CABLES

- .1 To power wiring and cables in this Section, with specific modifications and additional requirements under this Article.
- .2 Control Types: Provide the following:
 - .1 All: CLA1, installed to TIA-568.2, TIA-568.2, TIA-568.3.
- .3 Control Types Modified: If controller product manufacturer has specific requirements that are of a lesser quality than as indicated above, submit for review and agreement.
- .4 Raceways: Install in separate raceways from power and communication network wiring and cables.
- .5 Raceways Modified: Raceway requirements may be modified, unless otherwise required by regulation, as follows:
 - .1 Raceways are waived for the following:
 - .1 Circuits: Class 2 circuits to ESA-OESC that are less than 30-V.
 - .2 Purpose: Wiring and cables not for the purposes of life safety, including fire.
 - .3 Locations
 - .1 Walls, concealed.
 - .2 Concealed chases, service areas, behind other surfaces.
 - .3 Ceiling cavities, non-ducted return air plenums.
- .6 Components: Provide required additional components including signal conditioning and isolation, and other equipment and accessories.
- .7 Spare Lengths: Provide spare 0.5-m (1.6-ft) length at each termination.

3.7 RACEWAYS

- .1 Size: Fill raceways to the lesser of 40-% of free area, to ESA-OESC, to CSA-C22.1.
- .2 Installation and Routing
 - .1 Conceal raceways, except within mechanical, electrical or service rooms.
 - .2 Install and lay out raceways for drainage.
 - .3 Maintain 150-mm (6-in) minimum clearance from piping, ductwork or venting.
 - .4 Install raceways level, plumb, at right angles to building lines. Follow contours of supporting surfaces.
 - .5 Install bends and offsets uniformly without flattening.
 - .1 Bend raceways with minimum radius of 10-times nominal size of raceway.
- .3 Fittings
 - .1 Connections and Couplings: Provide throughout raceway installation, including at enclosures, boxes, and final terminations.
 - .2 Liquid Tight Connectors: Use as follows:
 - .1 Locations: Damp, wet, corrosive.
 - .2 Terminations: Final terminations to motors and vibrating equipment.
 - .3 Ends
 - .1 Provide insulated bushings on raceway ends.
 - .2 Cap and seal top end of vertical raceways.
 - .4 Expansion: Provide telescoping joints where raceways cross building expansion joints, complete with flexible copper ground jumper.
- .4 Pull Wire: Provide non-abrasive pull wire in each raceway, with 300-mm (12-in) of slack at either end, and ends terminated under a screw.
- .5 Enclosures and Boxes
 - .1 Pull Boxes: Provide pull boxes in raceways such that no wiring or cable will have to be pulled more than 2 90-degree bends or 30-m (100-ft) of raceways in 1 pulling operation.
 - .2 Junction Boxes: Provide as required, including for junctions and splices.

- .3 Covers: Provide new covers to enclosures or boxes missing covers. Use proper screws to secure covers.
- .4 Supports: Support enclosures and boxes independently of raceways and wiring and cables.

3.8 SUPPORTS AND HANGERS

- .1 Design and provide supports and hangers as required.
- .2 Support components and accessories independently of raceways.
- .3 Adjust support system including hangers to equalize load.

3.9 ACCESS HATCHES

- .1 Install as required.

3.10 PENETRATIONS

- .1 Provide sleeves at penetrations and where wiring passes through assemblies including walls, floors and ceilings.
- .2 Pack sleeves with resilient packing or fire rated packing and materials as required.
- .3 Flash parts built into or passing through to wet environments, waterproof assemblies, or exterior assemblies including roofs, outside walls.
- .4 Patch holes to match existing surfaces.
- .5 Provide minimum clearances as required between sleeves and uninsulated or insulated wiring with minimum of:
 - .1 Below Grade: 25-mm (1-in)
 - .2 Other Locations: 13-mm (1/2-in)
- .6 Sleeve Materials
 - .1 Exterior Assemblies: Carbon steel schedule 40, primed and painted.
 - .2 Masonry and Concrete Assemblies: Carbon steel schedule 40, primed and painted.
 - .3 Interior Frame Construction Assemblies in Conditioned Spaces: Carbon steel schedule 10.
 - .4 Other Frame Construction Assemblies: Carbon steel schedule 10 primed and painted.
- .7 Extend floor sleeves 38-mm (1-1/2-in) above floor surface.
- .8 Seal floor sleeves with an approved stiff setting caulking compound to serve as a water dam.

3.11 FIRE STOPPING AND SMOKE SEALS

- .1 Fire stop and smoke seal at fire-resistance rated assemblies including:
 - .1 Penetrations through masonry, concrete, and frame construction including gypsum board partitions and walls.
 - .2 Penetrations through floor slabs, ceilings and roofs.
 - .3 Openings and sleeves installed for future use.
 - .4 Services, including mechanical and electrical.
 - .5 As indicated.
- .2 Fire stop and smoke seal at non-fire-resistance rated assemblies including:
 - .1 Assemblies not fire-resistance rated but constructed as such.
 - .2 As indicated.
- .3 Install fire stopping and smoke seal material and components in accordance with manufacturer's certified tested system listing.
- .4 Install to allow for movement and thermal expansion of services including piping and ducting.
- .5 Ensure integrity of fire stopping and smoke seals such that passage of flame, smoke and gases is prevented including to unexposed side of assembly of single sided fire stopping and smoke seals. Repair as required.
- .6 Ensure integrity of insulation and vapour barriers. Repair as required.
- .7 Repair holes, gaps, openings and improperly fire stopped and smoke sealed penetrations in affected assemblies.
- .8 Provide tags for each fire stopping and smoke seal. Include relevant information on tags including installer name, company, trade license, installation date, fire stopping and smoke

seal ULC assembly number certification. Mount at locations as approved by Owner or as required by authorities having jurisdiction.

3.12 LABELLING

- .1 Labelling to match existing labelling scheme if possible and if approved by Owner, otherwise to meet Owner requirements.
- .2 Wiring and Cables
 - .1 Maintain consistent color-coding.
 - .2 Match colour coding of internal wiring and cables of pre-wired components where possible.
 - .3 Provide wire markers at the following locations.
 - .1 Both ends.
 - .2 At enclosures and boxes, including junction and pull boxes.
 - .3 At other terminations.
- .3 Controls and Communications Wiring and Cables
 - .1 Label with point or controls or network name with 3 rows of characters per label.
 - .2 Locations
 - .1 Both ends.
 - .2 At enclosures and boxes, including junction and pull boxes.
 - .3 At other terminations.
 - .3 Manufacturers
 - .1 Thomas & Betts Limited
 - .2 Brady Worldwide, Inc.
 - .4 Type: 12 character metalized polyester labels.
- .4 Enclosures and Boxes
 - .1 Label enclosures and boxes with permanent means, including junction and pull boxes.
 - .2 Identify purpose and power circuit(s).
- .5 Directories: Prepare updated written circuit directory on affected panels. Affix updated circuit directory to panel door, enclosed in a plastic protective sleeve.

END OF SECTION 26 05 00