



MECHANICAL SPECIFICATION

THP - ONCOLOGY RADIATION TREATMENT EXPANSION

TRILLIUM HEALTH PARTNERS

WSP PROJECT NO.: CA0003678.3329

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WSP
150 COMMERCE VALLEY DRIVE W.
THORNHILL, ON, CANADA L3T 7Z3

TEL.: +1 905 882-1100
FAX: +1 905 822-0055

WSP.COM

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PART 1 - GENERAL

1.1 References

- .1 Division 00 and Division 01 apply to and are a part of this Section.

1.2 Application

- .1 This Section specifies requirements that are common to Mechanical Divisions work Sections and it is a supplement to each Section and is to be read accordingly. Where requirements of this Section contradict requirements of Divisions 00 or 01, conditions of Division 00 or 01 to take precedence, as confirmed with Owner and reviewed with Consultant prior to Bid submission.
- .2 Be responsible for advising product vendors of requirements of this Section.

1.3 Definitions

- .1 "concealed" – means hidden from normal sight in furred spaces, shafts, ceiling spaces, walls and partitions.
- .2 "exposed" – means work normally visible, including work in equipment rooms, service tunnels, and similar spaces.
- .3 "finished" - means when in description of any area or part of an area or a product which receives a finish such as paint, or in case of a product may be factory finished.
- .4 "provision" or "provide" (and tenses of "provide") – means supply and install complete.
- .5 "install" (and tenses of "install") – means secure in position, connect complete, test, adjust, verify and certify.
- .6 "supply" – means to procure, arrange for delivery to site, inspect, accept delivery and administer supply of products; distribute to areas; and include manufacturer's supply of any special materials, standard on site testing, initial start-up, programming, basic commissioning, warranties and manufacturers' assistance to Contractor.
- .7 "delete" or "remove" (and tenses of "delete" or "remove") – means to disconnect, make safe, and remove obsolete materials; patch and repair/finish surfaces to match adjoining similar construction; include for associated re-programming of systems and/or change of documentation identifications to suit deletions, and properly dispose of deleted products off site unless otherwise instructed by Owner and reviewed with Consultant.
- .8 "barrier-free" – means when applied to a building and its facilities, that building and its facilities can be approached, entered and used by persons with physical or sensory disabilities in accordance with requirements of local governing building code.
- .9 "BAS" – means building automation system; "BMS" – means building management system; "FMS" – means facility management system; and "DDC" means direct digital controls; references to "BAS", "BMS", "FMS" and "DDC" generally mean same.
- .10 "governing authority" and/or "authority having jurisdiction" and/or "regulatory authority" and/or "Municipal authority" – means government departments, agencies, standards, rules and regulations that apply to and govern work and to which work must adhere.

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- .11 "OSHA" and "OHSA" – stands for Occupational Safety and Health Administration and Occupational Health and Safety Act, and wherever either one is used, they are to be read to mean local governing occupational health and safety regulations that apply to and govern work and to which work must adhere, regardless if Project falls within either authority's jurisdiction.
- .12 "Mechanical Divisions" – typically, refers to Divisions 20, 21, 22, 23, 25 and other Divisions as specifically noted, and which work as defined in Specifications and/or on drawings is responsibility of Mechanical Contractor, unless otherwise noted.
- .13 "Electrical Divisions" – typically, refers to Divisions 26, 27, 28 and other Divisions as specifically noted, and which work as defined in Specifications and/or on drawings is responsibility of Electrical Contractor, unless otherwise noted.
- .14 "Consultant" – means person, firm or corporation identified as such in Agreement or Documents, and is licensed to practice in Place of the Work, and has been appointed by Owner to act for Owner in a professional capacity in relation to the Work.
- .15 Wherever words "indicated", "shown", "noted", "listed", or similar words or phrases are used in Contract Documents they are understood, unless otherwise defined, to mean product referred to is "indicated", "shown", "listed", or "noted" on Contract Documents.
- .16 Wherever words "reviewed", "satisfactory", "as directed", "submit", or similar words or phrases are used in Contract Documents they are understood, unless otherwise defined, to mean that work or product referred to is "reviewed by", "to the satisfaction of", "submitted to", etc., Consultant.

1.4 Documents

- .1 Documents for bidding include but are not limited to issued Drawings, Specifications and Addenda.
- .2 Specification is typically generally arranged in coordination with guidelines of Construction Specifications Institute/Canadian Specifications Canada (CSI/CSC) 50 Division MasterFormat.
- .3 Drawings and Specifications are portions of Contract Documents and identify labour, products and services necessary for performance of work and form a basis for determining pricing. They are intended to be cooperative. Perform work that is shown, specified, or reasonably implied on the drawings but not mentioned in Specification, or vice-versa, as though fully covered by both.
- .4 Review Drawings and Specifications in conjunction with documents of other Divisions and, where applicable, Code Consultant's report.
- .5 Unless otherwise specifically noted in Specifications and/or on Drawings, Sections of Mechanical Divisions are not intended to delegate functions nor to delegate work and supply of materials to any specific trade, but rather to generally designate a basic unit of work, and Sections are to be read as a whole.
- .6 Drawings are performance drawings, diagrammatic, and show approximate locations of equipment and connecting services. Any information regarding accurate measurement of building is to be taken on site. Do not scale Drawings, and do not use Drawings for prefabrication work.

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- .7 Drawings are intended to convey the scope of work and do not show architectural and structural details. Provide, at your cost, offsets, fittings, transformations and similar products required as a result of obstructions and other architectural and/or structural details but not shown on Drawings.
- .8 Locations of equipment and materials shown may be altered, when reviewed by Consultant, to meet requirements of equipment and/or materials, other equipment or systems being installed, and of building, all at no additional cost to Contract.
- .9 Specification does not generally indicate specific number of items or amounts of material required. Specification is intended to provide product data and installation requirements. Refer to schedules, Drawings (layouts, riser diagrams, schematics, details) and Specification to provide correct quantities. Singular may be read as plural and vice versa.
- .10 Starter/motor control centre (MCC)/variable frequency drive (VFD) schedule drawings are both mechanical and electrical, and apply to work of Mechanical Divisions and Electrical Divisions. Be responsible for reviewing starter, MCC, VFD, and motor specification requirements prior to Bid submission. Confirm and coordinate exact scope of work and responsibility of work between Mechanical Divisions and Electrical Divisions.
- .11 If there is conflict or discrepancy between, among or within any provisions of Contract Documents, provisions establishing higher quality, manner or method of performing the Work, using more stringent standards, prevails, with intent that provisions which produce higher quality with higher levels of safety, reliability, durability, performance and service prevails.
- .12 Generally, documents govern in following order:
 - .1 Specification.
 - .2 Drawings of larger scale.
 - .3 Drawings of smaller scale.
 - .4 Drawings of later date when scale of drawings is same.
- .13 Upon finding discrepancies in, or omissions from Documents, or having doubt as to their meaning or intent, notify Consultant.
- .14 Drawings and Specifications have been prepared solely for use by party with whom Consultant has entered into a contract and there are no representations of any kind made by Consultant to any other party.

1.5 Metric and Imperial Measurements

- .1 Generally, both metric and imperial units of measurement are given in Sections of Specification governed by this section. Measurement conversions may be generally "soft" and rounded off. Confirm exact measurements based on application. Where measurements are related to installation and onsite applications, confirm issued document measurements with applicable local code requirements, and/or as applicable, make accurate measurements onsite. Where significant discrepancies are found, immediately notify Consultant for direction.

1.6 Examination of Documents and Site

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- .1 Carefully examine Documents and visit site to determine and review existing site conditions that will or may affect work, and include for such conditions in Bid Price.
- .2 Report to Consultant, prior to Bid Submittal, any existing site condition that will or may affect performance of work as per Documents. Failure to do so will not be grounds for additional costs.
- .3 Upon finding discrepancies in, or omissions from Documents, or having doubt as to their meaning or intent, immediately notify Consultant, in writing.

1.7 Work Standards

- .1 Where any code, regulation, bylaw, standard, contract form, manual, printed instruction, and installation and application instruction is quoted it means, unless otherwise specifically noted, latest published edition at time of submission of Bids adopted by and enforced by local governing authorities having jurisdiction. Include for compliance with revisions, bulletins, supplementary standards or amendments issued by local governing authorities.
- .2 Where regulatory codes, standards and regulations are at variance with Drawings and Specification, more stringent requirement will apply unless otherwise directed by Owner and reviewed with Consultant.
- .3 Supplementary mandatory specification and requirements to be used in conjunction with project include but are not limited to following:
 - .1 Air-Conditioning, Heating and Refrigeration Institute (AHRI);
 - .2 Air Movement and Control Association (AMCA);
 - .3 American Iron and Steel Institute (AISI);
 - .4 American National Standards Institute (ANSI);
 - .5 American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc., (ASHRAE);
 - .6 American Society of Mechanical Engineers (ASME);
 - .7 American Society of Testing and Materials (ASTM);
 - .8 American Water Works Association (AWWA);
 - .9 Associated Air Balance Council (AABC);
 - .10 Building Industry Consulting Services, International (BICSI);
 - .11 Canadian Gas Association (CGA);
 - .12 Canadian General Standards Board (CGSB);
 - .13 Canadian Standards Association (CSA);
 - .14 Electrical and Electronic Manufacturers Association of Canada (EEMAC);
 - .15 Electrical Safety Authority (ESA);
 - .16 Electronic Industries Association (EIA);
 - .17 Factory Mutual Systems (FM);
 - .18 Illuminating Engineering Society (IES);

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- .19 Institute of Electrical and Electronic Engineers (IEEE);
 - .20 International Standards Organization (ISO);
 - .21 Intertek's Electrical Testing Labs (ETL);
 - .22 Manufacturers Standardization Society of the Valve and Fittings Industry, Inc. (MSS);
 - .23 National Building Code of Canada (NBC);
 - .24 National Electrical Manufacturers Association (NEMA);
 - .25 National Environmental Balancing Bureau (NEBB);
 - .26 National Fire Protection Association (NFPA);
 - .27 National Standards of Canada;
 - .28 NSF International;
 - .29 Occupational Health and Safety Act (OHSA);
 - .30 Ontario Building Code (OBC);
 - .31 Ontario Electrical Safety Code (OESC);
 - .32 Sheet Metal and Air Conditioning Contractors' National Association (SMACNA);
 - .33 Technical Standards and Safety Authority (TSSA);
 - .34 Thermal Insulation Association of Canada (TIAC);
 - .35 Underwriters' Laboratories of Canada (ULC);
 - .36 Workplace Hazardous Materials Information System (WHMIS);
 - .37 Safety Data Sheets by product manufacturers;
 - .38 local utility inspection permits;
 - .39 Codes, standards, and regulations of local governing authorities having jurisdiction;
 - .40 additional codes and standards listed in Trade Sections;
 - .41 Owner's standards.
- .4 Provide applicable requirements for barrier free access in accordance with latest edition of local governing building code.
- .5 Where any governing Code, Regulation, or Standard requires preparation and submission of special details or drawings for review they are to be prepared and submitted to appropriate authorities. Be responsible for costs associated with these submittals.
- .6 Unless otherwise specified, install equipment in accordance with equipment manufacturer's recommendations and instructions, and requirements of governing Codes, Standards, and Regulations. Governing Codes, Standards, and Regulations take precedence over manufacturer's instructions. Notify Consultant in writing of conflicts between Contract Documents and manufacturer's instructions.

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- .7 Work is to be performed by journeyperson who perform only work that their certificates permit, or by apprentices under direct on site supervision of experienced journeyperson. Journeyperson to apprentice ratio is not to exceed ratio in accordance with requirements of Bill 47, Making Ontario Open for Business Act - 2018.
- .8 Journeyperson are to have a copy of valid trade certificates available at site for review with Consultant at any time.
- .9 Experienced and qualified superintendent is to be on-site at times when work is being performed.
- .10 Protect existing areas above, below and adjacent areas of Work from any debris, noise, or interruptions to existing services to satisfaction of Owner and reviewed with Consultant. Maintain in operation existing services to these areas to allow Owner to continue use of these areas. If services that are required to be maintained run through areas of renovations, provide necessary protection to services or reroute, in coordination with Owner and Consultant. Include for required premium time work to meet these requirements.
- .11 Work being performed within occupied spaces and work affecting surfaces adjacent to occupied spaces may need to be performed after regular business hours. For areas where spaces are used by Owner on a 24 hours basis or over various hours, coordinate hours of work with Owner on a regular basis to suit Owner's schedule. Execute work at times confirmed with and agreed to by Owner and reviewed with Consultant, so as not to inconvenience Owner's occupation or in any way hinder Owner's use of building. Include for required premium time work to meet these requirements.
- .12 Coordinate work inspection reviews and approvals with governing inspection department to ensure construction schedule is not delayed. Be responsible for prompt notification of deficiencies to Consultant and submission of reports and certificates to Consultant.
- .13 Properly protect equipment and materials on site from damage and defacement due to elements and work of trades, to satisfaction of Owner and reviewed with Consultant. Equipment and materials are to be in new condition upon Substantial Performance of the Work.
- .14 Mechanical piping system work, including equipment, must comply with requirements of local technical standards authorities and CSA B51, Boiler, Pressure Vessels and Pressure Piping Code. Where required, mechanical work products are to bear a Canadian Registration Number (CRN) number.
- .15 Electrical items associated with mechanical equipment are to be certified and bear stamp or seal of a recognized testing agency such as CSA, UL, ULC, ETL, etc., or bear a stamp to indicate special electrical utility approval.

1.8 Healthcare Facility Standards

- .1 Comply with following standards:
 - .1 CSA Z317.1, Special Requirements for Plumbing Installations in Health Care Facilities.
 - .2 CSA Z317.2, Special Requirements for Heating, Ventilation, and Air-Conditioning (HVAC) Systems in Health Care Facilities.
 - .3 CSA Z317.10, Handling of Health Care Waste Materials .

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- .4 CAN/CSA Z317.13, Infection Control During Construction, Renovation, and Maintenance of Health Care Facilities.
- .5 CSA Z7396.1 Medical Gas Pipeline Systems - Part 1 Pipelines for Medical Gases, Medical Vacuum, Medical Support Gases, and Anaesthetic Gas Scavenging Systems.
- .6 CSA Z8000, Canadian Health Care Facilities.
- .7 CAN/CSA Z8001, Commissioning of Health Care Facilities.
- .2 Prepare a list of areas of the work where infection control procedures are to be in force and review list and procedures with healthcare facility's Infection Control Officer or a designated healthcare facility representative prior to commencing work in aforementioned areas. As work proceeds, ensure infection control procedures are being maintained.
- .3 Comply with healthcare facility's latest policies and procedures regarding infection prevention and decontamination measures during work of project. Refer to additional requirements of Division 01.

1.9 Permits, Certificates, Approvals and Fees

- .1 Contact and confirm with local authorities having jurisdiction including utility providers, requirements for approvals from such authorities. Obtain and pay for permits, certificates, and approvals required to complete Work.
- .2 Be responsible for ensuring that authorities having jurisdiction which require on-site inspection of work, have ample notification to perform inspection, with sufficient lead time to correct deficiencies in a manner that will not impede schedule of completion of Work. If any defect, deficiency or non-compliant is found in work by inspection, be responsible for costs of such inspection, including any related expenses, making good and return to site, until work is passed by governing authorities.
- .3 Obtain and submit to Consultant, approval/inspection certificates issued by governing authorities to confirm that Work as installed is in accordance with rules and regulations of local governing authorities and are acceptable.
- .4 Include in each copy of operating and maintenance instruction manuals, copies of approvals and inspection certificates issued by regulatory authorities.

1.10 Requirements for Contractor Retained Engineers

- .1 Professional engineers retained to perform consulting services with regard to Project work, i.e. seismic engineer, fire protection engineer or structural engineer, are to be legally qualified to practice professional engineering in the Place of the Work, and are to carry and pay for errors and omissions professional liability insurance in compliance with requirements of governing authorities in Place of the Work.
- .2 Retained engineer's professional liability insurance is to protect Contractor's consultants and their respective servants, agents, and employees against any loss or damage resulting from professional services rendered by aforementioned consultants and their respective servants, agents, and employees in regards to the Work of this Contract.
- .3 Unless otherwise specified in Division 00 or 01, liability insurance requirements are as follows:

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- .1 coverage is to be a minimum of \$1,000,000.00 CDN inclusive of any one occurrence;
- .2 insurance policy is not to be cancelled or changed in any way without insurer giving Owner minimum thirty days written notice;
- .3 liability insurance is to be obtained from an insurer registered and licensed to underwrite such insurance in the Place of the Work;
- .4 retained consultants are to ascertain that sub-consultants employed by them carry insurance in the form and limits specified above;
- .5 evidence of the required liability insurance in such form as may be required is to be issued to Owner, Owner's Consultant, and Municipal Authorities as required prior to commencement of aforementioned consultant's services.

1.11 Workplace Safety

- .1 Comply with requirements of Workplace Hazardous Materials Information System (WHMIS) regarding use, handling, storage and disposal of hazardous materials. Submit WHMIS SDS (Safety Data Sheets) for products where required, and maintain one copy at site in a visible and accessible location available to personnel.
- .2 Comply with requirements of Occupational Health and Safety Act and other regulations pertaining to health and safety, including worker's compensation/insurance board and fall protection regulations. When working in confined spaces, comply with requirements of Occupational Health and Safety Act - Ontario Regulation 632, "Confined Spaces" and any other applicable Ministry of Labour requirements.
- .3 If at any time during course of existing building work, hazardous materials other than those identified in Documents and pertaining to Project Scope of Work, are encountered or suspected that were not identified as being present and which specific instructions in handling of such materials were not given, cease work in area in question and immediately notify Consultant. Comply with local governing regulations with regards to working in areas suspected of containing hazardous materials. Do not resume work in affected area without approval from Owner and reviewed with Consultant.

1.12 Planning and Layout of Work

- .1 Base installation layout, design, terminations, and supply of accessories, on Contract Documents with specific coordination with reviewed shop drawings.
- .2 Plan, coordinate, and establish exact locations and routing of services with affected trades prior to installation such that services clear each other as well as other obstructions. Generally, as coordinated prior to start of Work with each trade and with Owner and reviewed with Consultant, to suit specific project requirements, order of right of way for services to be as follows:
 - .1 piping requiring uniform pitch;
 - .2 piping 100 mm (4") dia. and larger;
 - .3 large ducts (main runs);
 - .4 cable tray and bus duct;
 - .5 conduit 100 mm (4") dia. and larger;

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- .6 piping less than 100 mm (4") dia.;
- .7 smaller branch ductwork;
- .8 conduit less than 100 mm (4") dia..
- .3 Unless otherwise shown or specified, conceal work in finished areas, and conceal work in partially finished and/or unfinished areas to extent made possible by the area construction. Install services as high as possible to conserve headroom and/or ceiling space. Notify Consultant where headroom or ceiling space appears to be inadequate prior to installation of work.
- .4 Do not use Contract Drawing measurements for prefabrication and layout of piping, sheet metal work and such other work. Locations and routing are to generally be in accordance with Contract Drawings, however, prepare layout drawings for such work. Use established bench marks for both horizontal and vertical measurements. Confirm inverts, coordinate with and make allowances for work of other trades. Accurately layout work, and be entirely responsible for work installed in accordance with layout drawings. Where any invert, grade, or size is at variance with Contract Drawings, notify Consultant prior to proceeding with work.
- .5 Prepare plan and interference drawings (at a minimum drawing scale of 1:50 or 1/4"=1' 0") of work for coordination with each trade Contractor. Arrange for preparation of detailed section drawings of ceiling spaces of corridors and any other congested areas. Sections are to be cross referenced with plan drawings so that trades may make use of section drawings. Section drawings to indicate lateral and elevation dimensions of major services within ceiling space. Lateral dimensions are to be from grid lines and elevations from top of floor slab. Obtain from Consultant, engineering drawings for this use. Contractors' interference drawings are to be distributed among other Trade Contractors. Submit drawings to Consultant for review. Failure of General Contractor to prepare and coordinate overall interface drawings of trades does not relieve respective Division Contractor of responsibility to ensure that work is properly planned and coordinated.
- .6 Carry out alterations in arrangement of work that has been installed without proper coordination, study, and review, even if in accordance with Contract Documents, in order to conceal work behind finishes, or to allow installation of other work, without additional cost. In addition, make necessary alterations in other work required by such alterations, without additional cost.
- .7 Locate shut-off valves, balancing devices, air vents, equipment and similar products, particularly such products located above suspended ceilings, for easy access for servicing and/or removal. Relocate products which do not meet this location requirement to accessible location, at no additional cost.
- .8 Be responsible for making necessary changes, at no additional cost, to accommodate structural and building conditions that were missed due to lack of coordination.
- .9 Where drawings indicate that acoustic tile ceiling is being suspended below structural ceiling, coordinate design of framework used to support suspended ceiling, diffusers, and other Divisions components that are mounted within or through ceiling. Do not mount devices to suspended ceiling. Secure and mount to ceiling slab above. Seal ceiling openings to maintain required fire rating.

1.13 Phasing

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- .1 Phasing and scheduling of Work is required in order to maintain existing building operations. Include costs (including costs for "off hours" work) for scheduling, coordination, and construction phasing to suit this project as specified in Division 01 and on drawings. Review phasing requirements with Consultant prior to start of Work.
- .2 Project partial occupancy permits to be required throughout project. Provide for each partial permit, required local governing authority certificate and any other testing/verification certificates for systems.

1.14 Coordination of Work

- .1 Review Contract Documents and coordinate work with work of each trade. Coordination requirements are to include but not be limited to following:
 - .1 requirements for openings, sleeves, inserts and other hardware necessary for installation of work;
 - .2 concrete work such as housekeeping pads, sumps, bases, etc., required for work, and including required dimensions, operating weight of equipment, location, etc.;
 - .3 depth and routing of excavation required for work, and requirements for bedding and backfill;
 - .4 wiring work required for equipment and systems but not specified to be done as part of mechanical work, including termination points, wiring type and size, and any other requirements.
- .2 Ensure materials and equipment are delivered to site at proper time and in such assemblies and sizes so as to enter into building and be moved into spaces where they are to be located without difficulty.
- .3 Wherever possible, coordinate equipment deliveries with manufacturers and/or suppliers so equipment is delivered to site when it is required, or so it can be stored within building, subject to available space as confirmed with Owner and reviewed with Owner, and protected from elements.
- .4 Ensure proper access and service clearances are maintained around equipment, and, where applicable, access space for future equipment removal or replacement is not impeded. Comply with code requirements with regards to access space provision around equipment. In coordination with Owner and review with Consultant, relocate equipment which does not meet this requirement.
- .5 Where work is to be integrated, or is to be installed in close proximity with work of other trades, coordinate work prior to and during installation.

1.15 Products

- .1 Order products (equipment and materials) in a timely manner to meet project-scheduling timelines. Failure to order products to allow manufacturers sufficient production/delivery time to meet project-scheduling timelines is unacceptable reason to request for use of other suppliers or substitutions.
- .2 Provide Canadian manufactured products wherever possible or required and when quality and performance is obtainable at a competitive price. Products are to be supplied from manufacturer's authorized Canadian representative, unless otherwise noted. Unless otherwise specified, products are to be new.

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- .3 Products are to comply with applicable respective Canadian standards, and typically with Canadian Standards Association (CSA) approvals and/or Underwriters Laboratories of Canada (ULC) listings markings. References to UL listings of products to include requirements that products are to be also Underwriters Laboratories of Canada ULC / cUL listed for use in Canada. Other certification organizations accredited by Standards Council of Canada to approve electrical equipment may be acceptable subject to approval from local governing electrical authority and review with Consultant. Applicable products are to meet or exceed latest ANSI/ASHRAE/IES 90.1 standards enforced by local governing authorities.
- .4 Systems and equipment of this Project are to be "State of the Art" and be most recent and up to date series/version of product that is available at time of shop drawing review process. Products that have been stored or "on shelf" for an extended period of time will not be accepted. Software is to be of latest version available and be provided with updates available at time of shop drawing review process. Systems are to be designed such that its software is backwards compatible. Future upgrades are not to require any hardware replacements or additions to utilize latest software.
- .5 Products scheduled and/or specified have been selected to establish a performance and quality standard, and, in some instances, a dimensional standard. In most cases, base specified manufacturers are stated for any product specified by manufacturer's name and model number. Where acceptable manufacturers are listed, first name listed is base specified company. Bid Price may be based on products supplied by any of manufacturers' base specified or named as acceptable for particular product. If acceptable manufacturers are not stated for a particular product, base Bid Price on product supplied by base specified manufacturer.
- .6 Documents have been prepared based on product available at time of Bidding. If, after award of Contract, and if successful manufacturer can no longer supply a product that meets base specifications, notify Consultant immediately. Be responsible for obtaining other manufacturers product that complies with base specified performance and criteria and meets project timelines. Proposed products are subject to review and consideration by Consultant and are considered as substitutions subject to a credit to Contract. In addition, if such products require modifications to room spaces, mechanical systems, electrical systems, etc., include required changes. Such changes are to be submitted in detail to Consultant for review and consideration for acceptance. There will be no increase in Contract Price for revisions. Above conditions supplement and are not to supersede any specification conditions with regards to substitutions or failure to supply product as per issued documents.
- .7 Listing of a product as "acceptable" does not imply automatic acceptance by Consultant and/or Owner. It is responsibility of Contractor to ensure that any price quotations received and submittals made are for products that meet or exceed specifications included herein.

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- .8 If products supplied by a manufacturer named as acceptable are used in lieu of base specified manufacturer, be responsible for ensuring that they are equivalent in performance and operating characteristics (including energy consumption if applicable) to base specified products. It is understood that any additional costs (i.e. for larger starters, larger feeders, additional spaces, etc.), and changes to associated or adjacent work resulting from provision of product supplied by a manufacturer other than base specified manufacturer, is included in Bid Price. In addition, in equipment spaces where equipment named as acceptable is used in lieu of base specified equipment and dimensions of such equipment differs from base specified equipment, prepare and submit for review accurately dimensioned layouts of rooms affected, identifying architectural and structural elements, systems and equipment to prove that equipment in room will fit properly meeting design intent. There will be no increase in Contract Price for revisions.
- .9 Where products are listed as "or approved equal", certify in writing that product to be used in lieu of base specified product, at least meets space, power, design, energy consumption, and other requirements of base specified product and is equivalent or better than base specified product. When requested by Consultant, provide full design detail drawings and specifications of proposed products. Acceptance of these "or approved equal" products is at sole discretion of Consultant. It is understood that there will be no increase in Contract Price by reason of any changes to associated equipment, mechanically, electrically, structurally or architecturally, required by acceptance of approved equal product. There must be no increase in Contract price due to Consultant's rejection of proposed equivalent product.
- .10 Whenever use of product other than base specified product is being supplied, ensure corresponding certifications and product information (detailed catalogue and engineering data, fabrication information and performance characteristics) are submitted to Consultant for review. Failure of submission of these documents to Consultant in a timely manner to allow for review will result in base specified product to be supplied at Consultant's discretion, at no additional cost to Contract.
- .11 In addition to manufacturer's products base specified or named as acceptable, other manufacturers of products may be proposed as substitutions to Consultant for review and consideration for acceptance, listing in each case a corresponding credit for each substitution proposed. However, base Bid Price on products base specified or named as acceptable. Certify in writing to Consultant that proposed substitution meets space, power, design, energy consumption, and other requirements of base specified or acceptable product. It is understood that there will be no increase in Contract Price by reason of any changes to associated equipment, mechanically, electrically, structurally or architecturally, required by acceptance of proposed substitution. Consultant has sole discretion in accepting any such proposed substitution of product. Indicate any proposed substitutions in areas provided on Bid Form. Do not order such products until they are approved by Owner and reviewed in writing with and recommended for acceptance by Consultant.
- .12 Substitutions will not be considered by Consultant during Bid period unless:
 - .1 permitted by Owner;
 - .2 directions and submission areas are provided on Bid Form;
 - .3 or formally requested in writing a minimum of 10 working days prior to Bid closing date.

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- .13 When issued with Documents, complete and submit as directed, Appendix - List of Acceptable Manufacturers and Suppliers, or when directed by Consultant submit separate list of proposed manufacturers and suppliers.
- .14 Any proposed changes to list of manufacturers initiated by Contractor after award of Contract may be considered by Consultant at Consultant's discretion, with any additional costs for such changes if approved by Owner and reviewed with and recommended by Consultant, and costs for review, to be borne by Contractor.
- .15 Whenever use of product other than based specified products or named as acceptable is being supplied, allow sufficient time for processing of product submissions and time for Consultant's review, such that there will not be significant impact on contract time or work schedule.

1.16 Non-Ferrous Materials

- .1 Materials within designated imaging rooms to be of non-ferrous construction as reviewed with Consultant. Devices, system components, etc., utilized to be approved for use in designated imaging room type applications. Methods of construction to take into consideration use of non-ferrous materials. Ultimate approval of any materials, devices or components, or methods of construction to be at imaging system manufacturer's discretion. Coordinate and confirm final requirements with successful imaging system supplier.

1.17 Shop Drawings

- .1 At start-up meeting, review with Consultant products to be included in shop drawing submission. Prepare and submit list of products to Consultant for review.
- .2 Submit electronic copies of shop drawings unless otherwise directed by Consultant. Coordinate exact requirements with Consultant.
- .3 Submit for review, drawings showing detail design, construction, and performance of equipment and materials as requested in Specification. Submit shop drawings to Consultant for review prior to ordering and delivery of product to site. Include minimally for preparation and submission of following, as applicable:
 - .1 product literature cuts;
 - .2 equipment data sheets;
 - .3 equipment dimension drawings;
 - .4 system block diagrams;
 - .5 sequence of operation;
 - .6 connection wiring schematic diagrams;
 - .7 functionality with integrated systems.
- .4 Each shop drawing or product data sheet is to be properly identified with project name and product drawing or specification reference. Shop drawing or product data sheet dimensions are to match dimension type on drawings.
- .5 Where any item of equipment is required by Code or Standard or By-Law to meet a specific energy efficiency level, or any other specific requirement, ensure this requirement is clearly indicated on submission.

Mechanical Work General Instructions

- .6 Ensure proposed products meet each requirement of Project. Endorse each shop drawing copy "CERTIFIED TO BE IN ACCORDANCE WITH ALL REQUIREMENTS". Include company name, submittal date, and sign each copy. Shop drawings that are received and are not endorsed, dated and signed will be returned to be resubmitted.
- .7 Consultant to review shop drawings and indicate review status by stamping shop drawing copies as follows:
 - .1 "REVIEWED" or "REVIEWED AS NOTED" (appropriately marked) – If Consultant's review of shop drawing is final, Consultant to stamp shop drawing;
 - .2 "REVISE & RESUBMIT" – If Consultant's review of shop drawing is not final, Consultant to stamp shop drawing as stated above, mark submission with comments, and return submission. Revise shop drawing in accordance with Consultant's notations and resubmit.
- .8 Following is to be read in conjunction with wording on Consultant's shop drawing review stamp applied to each and every shop drawing or product data sheet submitted:

"THIS REVIEW BY CONSULTANT IS FOR SOLE PURPOSE OF ASCERTAINING CONFORMANCE WITH GENERAL DESIGN CONCEPT. THIS REVIEW DOES NOT MEAN THAT CONSULTANT APPROVES DETAILED DESIGN INHERENT IN SHOP DRAWINGS, RESPONSIBILITY FOR WHICH REMAINS WITH CONTRACTOR. CONSULTANT'S REVIEW DOES NOT RELIEVE CONTRACTOR OF RESPONSIBILITY FOR ERRORS OR OMISSIONS IN SHOP DRAWINGS OR OF CONTRACTOR'S RESPONSIBILITY FOR MEETING REQUIREMENTS OF CONTRACT DOCUMENTS. BE RESPONSIBLE FOR DIMENSIONS TO BE CONFIRMED AND CORRELATED AT JOB SITE, FOR INFORMATION THAT PERTAINS SOLELY TO FABRICATION PROCESSES OR TO TECHNIQUES OF CONSTRUCTION AND INSTALLATION, AND FOR COORDINATION OF WORK OF SUB-TRADES."
- .9 Submit each system and each major component as separate shop drawing submissions. Submit together, shop drawings for common devices such as devices of each system are to be submitted together.
- .10 Obtain shop drawings for submission from product manufacturer's authorized representatives and supplemented with additional items specified herein.
- .11 Do not order product until respective shop drawing review process has been properly reviewed with Consultant.
- .12 Where extended warranties are specified for equipment items, submit specified extended warranty with shop drawing submittal.
- .13 Refer to specific requirements in other Sections.
- .14 Applicable mechanical equipment has been selected to meet energy efficiency requirements of ANSI/ASHRAE/IES 90.1, Energy Standards for Buildings, and shop drawings/product data submittals for such equipment are to indicate compliance with this Standard or they will be returned for correction and re-submittal.

1.18 Engineered Submittals

Mechanical Work General Instructions

- .1 Submittals for items required to be sealed by a professional engineer (engineered) are to be duly prepared, sealed, and signed under direct control and supervision of a qualified professional engineer licensed in jurisdiction of the work. Professional engineer is to conform to requirements specified in this Section in article entitled Requirements for Contractor Retained Engineers.
- .2 Engineered submittals are to include, but not be limited to, following:
 - .1 complete CAD layout drawings indicating equipment, piping schematic, pipe routing and sizing, zones, devices, wiring schematics, and any other pertinent data;
 - .2 listing of design data used to determine system layout and sizing;
 - .3 complete copies of design calculations and listing of design data used in preparing calculations;
 - .4 list detailing standards, codes, regulations, etc. adhered to when designing system;
 - .5 items as noted in other Sections of the Specification.
- .3 Professional engineer responsible for engineered submittals is to perform periodic field reviews, including review of associated mock-ups where applicable, at locations wherever work as described by engineered submittal is in progress, during fabrication and installation of such work, and submit a field review report after each visit. Submit field review reports to Consultant and authorities having jurisdiction as required.
- .4 Field reviews are to be at intervals as necessary and appropriate to progress of work described by engineered submittal to allow engineer to be familiar with progress and quality of such work and to determine if work is proceeding in general conformity with Contract Documents including reviewed shop drawings and design calculations.
- .5 Upon completion of work as described by engineered submittal, professional engineer responsible for preparation of engineered submittal and for performing periodic field reviews is to prepare and submit to Consultant and, if applicable, authorities having jurisdiction, a letter certifying that work has been supplied and installed in accordance with requirements of Contract Documents, authorities having jurisdiction and engineered submittal.

1.19 Equipment Loads

- .1 Supply equipment loads (self-weight, operating weight, housekeeping pad, inertia pads, etc.) to Consultant, via shop drawing submissions, prior to construction.
- .2 Where given choice of specific equipment, actual weight, location and method of support of equipment may differ from those assumed by Consultant for base design. Back-check equipment loads, location, and supports, and include necessary accommodations.
- .3 Where supporting structure consists of structural steel framing, it is imperative that equipment loads, location, and method of support be confirmed prior to fabrication of structural steel. Review locations of equipment with Consultant prior to construction.

1.20 Openings

- .1 Supply opening sizes and locations to Consultant to allow verification of their effect on design, and for inclusion on structural drawings where appropriate.

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- .2 No openings are permitted through completed structure without written approval from Owner and reviewed with Consultant. Show required openings on a copy of structural drawings. Identify exact locations, elevations, and size of proposed openings and submit to Consultant for review, well in advance of doing work.
- .3 Prior to leaving site at end of each day, walk through areas of work and check for any openings, penetrations, holes, and/or voids created under scope of work of project, and ensure that any openings created under scope of work have been closed off, fire-stopped and smoke-sealed. Unless otherwise directed by Owner and reviewed with Consultant, do not leave any openings unprotected and unfinished overnight.

1.21 Scaffolding, Hoisting and Rigging

- .1 Unless otherwise specified or directed, supply, erect and operate scaffolding, rigging, hoisting equipment and associated hardware required for work, and subject to approval from Owner and reviewed with Consultant.
- .2 Use scaffolds in such a manner as to interfere as little as possible with work of other trades.
- .3 Do not place major scaffolding/hoisting equipment loads on any portion of structure without approval from Owner and reviewed with Consultant. No supports, clips, brackets or similar devices are to be welded, bolted or otherwise affixed to any finished member or surface without approval from Owner and review with Consultant.
- .4 Immediately remove from site scaffolding, rigging and hoisting equipment when no longer required.

1.22 REQUEST FOR INFORMATION (RFI)

- .1 Review contract documents for information prior to issuance of RFI during performance of Work. Where it is determined, at discretion of Owner and Consultant, that information requested in RFI was readily identifiable as part of contract documents, respective trades Contractor to be back-charged against their contract amount for time spent by Consultant and/or Owner in preparing response to RFI. Minimum amount of \$150 CDN plus GST to be back charged against contract amount for any response to a readily identifiable RFI.

1.23 Changes in the Work

- .1 Whenever Consultant proposes in writing to make a change or revision to design, arrangement, quantity or type of work from that required by Contract Documents, prepare and submit to Consultant for review, a quotation detailing proposed cost for executing change or revision.
- .2 Quotation is to be a detailed and itemized estimate of product, labour, and equipment costs associated with change or revision, plus overhead and profit percentages and applicable taxes and duties.
- .3 If overhead and profit percentages are not specified in Division 00 or 01, but allowable under Contract as reviewed with Consultant prior to contract signing, then allowable maximum percentages for overhead and profit are to be 5% for each.
- .4 Unless otherwise specified in Divisions 00 or 01, following additional requirements apply to all quotations submitted:

Mechanical Work General Instructions

- .1 when change or revision involves deleted work as well as additional work, cost of deleted work (less overhead and profit percentages but including taxes and duties) is to be subtracted from cost of additional work before overhead and profit percentages are applied to additional work;
 - .2 material costs are not to exceed those published in local estimating price guides with additional reductions as follows:
 - .1 steel pipe: 50%;
 - .2 copper pipe: 45%;
 - .3 cast iron soil pipe: 45%;
 - .4 stainless steel pipe and fittings: 45%;
 - .5 welded fittings: 50%;
 - .6 grooved fittings: 30%;
 - .7 threaded fittings: 40%;
 - .8 cast iron screwed fittings: 40%;
 - .9 copper fittings: 45%;
 - .10 cast iron MJ fittings: 35%;
 - .11 valves: 25%;
 - .12 insulation materials: 35%;
 - .13 all other materials: 20%.
 - .3 mechanical labour unit costs are to be in accordance with Mechanical Contractors Association of America Labor Estimating Manual, less 25%;
 - .4 electrical labour unit costs are to be in accordance with National Electrical Contractors Association Manual of Labor Units at difficult level, less 25%;
 - .5 costs for journeyman and apprentice labour must not exceed prevailing rates at time of execution of Contract and must reflect actual personnel performing work;
 - .6 cost for site superintendent must not exceed 10% of total hours of labour estimated for change or revision, and change or revision must be such that site superintendent's involvement is necessary;
 - .7 costs for rental tools and/or equipment are not to exceed local rental costs;
 - .8 overhead percentage will be deemed to cover quotation costs other than actual site labour and materials, and rentals;
 - .9 quotations, including those for deleted work, to include a figure for any required change to Contract time.
- .5 Quotations submitted that are not in accordance with requirements specified above will be rejected and returned for re-submittal. Failure to submit a proper quotation to enable Consultant to expeditiously process quotation and issue a Change Order will not be grounds for any additional change to Contract time.

Mechanical Work General Instructions

- .6 Make requests for changes or revisions to work in writing to Consultant and, if accepted by Owner, Notice of Change or Change Directive to be issued.
- .7 Do not execute any change or revision until written authorization for the change or revision has been obtained from Consultant.

1.24 Progress Payment Breakdown

- .1 Prior to submittal of first progress payment draw, submit a detailed breakdown of work cost to assist Consultant in reviewing and approving progress payment claims.
- .2 Payment breakdown is subject to Owner's approval and Consultant's review and recommendations. Progress payments will not be processed until an approved breakdown is in place. Breakdown is to include one-time claim items such as mobilization and demobilization, insurance, bonds (if applicable), shop drawings and product data sheets, commissioning including testing, adjusting and balancing, system testing and verification, and project closeout submittals.
- .3 Indicate equipment, material and labour costs for site services (if applicable) and indicate work of each trade in same manner as indicated on progress draw.

1.25 Notice for Required Field Reviews

- .1 Whenever there is a requirement for Consultant to perform a field review prior to concealment of any work, to inspect/re-inspect work for deficiencies prior to Substantial Performance of the Work, for commissioning demonstrations, and any other such field review, give minimum 7 working days' notice in writing to Consultant.
- .2 If Consultant is unable to attend a field review when requested, arrange an alternative date and time.
- .3 Do not conceal work until Consultant advises that it may be concealed.
- .4 When Consultant is requested to perform a field review and work is not ready to be reviewed, reimburse Consultant for time and travel expenses.

1.26 Preliminary Testing

- .1 When directed by Consultant, promptly arrange, pay for, and perform site tests on any piece of equipment or any system for such reasonable lengths of time and at such times as may be required to prove compliance with Specification and governing Codes and Regulations, prior to Substantial Performance of the Work.
- .2 When, in Consultant's opinion, tests are required to be performed by a certified testing laboratory, arrange and pay for such tests.
- .3 These tests are not to be construed as evidence of acceptance of work, and it is agreed and understood that no claim for delays or damage will be made for injury or breakage to any part or parts of equipment or system due to test where such injuries or breakage were caused by faulty parts and/or workmanship of any kind.
- .4 When, in Consultant's opinion, tests indicate that equipment, products, etc., are defective or deficient, immediately remove such equipment and/or products from site and replace them with acceptable equipment and/or products, at no additional cost.

1.27 Provisions for Systems/Equipment Used During Construction

Mechanical Work General Instructions

- .1 Permanent building mechanical systems are not to be used for temporary heating or cooling purposes during construction.
- .2 Permanent mechanical systems in building may be used for temporary heating or cooling during construction subject to following conditions:
 - .1 each entire system is complete, pressure tested, cleaned, and flushed out;
 - .2 specified water treatment system has been commissioned, and treatment is being continuously monitored;
 - .3 building has been closed in and areas to be heated/ventilated are clean and will not thereafter be subjected to dust-producing processes;
 - .4 there is no possibility of damage from any cause;
 - .5 supply ventilation systems are protected by 60% filters, which are to be inspected daily, and changed every 2 weeks, or more frequently as required;
 - .6 return air systems have approved construction filters over openings, inlets, and outlets;
 - .7 systems are operated in accordance with manufacturer's recommendations or instructions, and are monitored on a regular and frequent basis;
 - .8 warranties are not affected in any way;
 - .9 regular preventive and other manufacturer's recommended maintenance routines are performed;
 - .10 before application for Certificate of Substantial Performance, each entire system is to be refurbished, cleaned internally and externally, restored to "as-new" condition, and filters in air systems replaced;
 - .11 energy costs are to be paid by Contractor.
- .3 Confirm with Consultant what equipment can be used during construction.
- .4 Any system or piece of equipment that is specified to be provided under requirements of Documents and is required to be used during construction stages of work prior to issuing of Certificate of Substantial Performance of the Work, are to be provided with special interim maintenance and service to cover systems/equipment during time of use during construction period of project until project has been certified as substantially performed and such systems/equipment are turned over to Owner.
- .5 During this period of construction, such systems/equipment to not become property of Owner or be Owner's responsibility for maintenance or service. Systems/equipment are to remain property of respective manufacturers/suppliers or Contractor, who are responsible for full maintenance and servicing of systems/equipment in order to maintain validity of warranties after turn over to Owner.
- .6 Prior to application for a Certificate of Substantial Performance of the Work and turn over to Owner, such systems/equipment to be cleaned, restored to "new" condition, paint finishes "touched-up", filters cleaned or replaced, etc.

1.28 Temporary Services

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- .1 Coordinate with Prime Contractor, requirements for temporary services including but not limited to temporary heating, cooling and water. Unless otherwise noted, provide required services in compliance with requirements of local governing building code and local governing inspection authorities.
- .2 Maintain fire protection of areas which may include fire watch during temporary shutdowns of existing systems, in accordance with requirements of local governing code and local governing authorities.

1.29 Maintaining Equipment Prior to Acceptance

- .1 Maintain equipment in accordance with manufacturer's instructions prior to start-up, testing and commissioning.
- .2 Employ a qualified millwright to check and align shafts, drives, and couplings on all base mounted split coupled motor driven equipment.
- .3 Where equipment lubrication fittings are not easily accessible, extend the fittings to accessible locations using copper or aluminium tubing.
- .4 All filters are to be new upon Substantial Performance of the Work. This is in addition to any spare filters specified.

1.30 Cleaning

- .1 During construction, keep site reasonably clear of rubbish and waste material resulting from work on a daily basis to the satisfaction of Owner and Consultant. Before applying for a Certificate of Substantial Performance of the Work, remove rubbish and debris, and be responsible for repair of any damage caused as a result of work.
- .2 Clean equipment and devices installed as part of this project.

1.31 Record As-Built Drawings

- .1 Drawings for this project have been prepared on a CAD system using AutoCAD software of release version reviewed with Consultant. For purpose of producing record "as built" drawings, copies of Contract Drawings can be obtained from Consultant, at expense of \$200 CDN initial base plus \$25.00 CDN per drawing up to first 10 drawings, and \$5.00 per any additional drawings thereafter. HST charged additionally. Drawings may also be used for preparation of layouts and interference drawings.
- .2 Drawings for this project have been prepared on a CAD system using Building Information Modelling (BIM) - Autodesk Revit Architecture (Revit) software of release version confirmed with Consultant. For purpose of producing record "as built" drawings, copies of Contract Drawings can be obtained from Consultant, at expense of \$200 CDN initial base plus \$25.00 CDN per drawing up to first 10 drawings, and \$5.00 per any additional drawings thereafter. HST charged additionally. Drawings may also be used for preparation of layouts and interference drawings.
- .3 Drawings for this project have been prepared on a CAD system using AutoCAD software of release version reviewed with Consultant. For purpose of producing record "as built" drawings, copies of Contract Drawings can be obtained from Consultant.

Mechanical Work General Instructions

- .4 As work progresses at site, clearly mark in red in a neat and legible manner on a set of bound white prints of Contract Drawings, changes and deviations from routing of services and locations of equipment shown on Contract Drawings, on a daily basis. Changes and deviations include those made by addenda, change orders, and site instructions. Use notes marked in red as required. Maintain white print red line as-built set at site for exclusive use of recording as-built conditions, keep set up-to-date at all times, and ensure set is always available for periodic review. As-built set is also to include the following:
 - .1 dimensioned location of inaccessible concealed work;
 - .2 locations of control devices with identification for each;
 - .3 for underground piping and ducts, record dimensions, invert elevations, offsets, fittings, cathodic protection and accessories if applicable, and locate dimensions from benchmarks to be preserved after construction is complete;
 - .4 for fire protection systems, record actual locations of equipment, sprinkler heads, and valves, drains, and test locations, and deviations of pipe routing and sizing from that shown on the drawings;
 - .5 location of piping system air vents;
 - .6 location of concealed services terminated for future extension and work concealed within building in inaccessible locations.
- .5 Before applying for a Certificate of Substantial Performance of the Work, update a clean copy of Contract Drawing set in accordance with marked up set of "as-built" white prints including deviations from original Contract Drawings, thus forming an "as-built" drawing set. Submit "as-built" site drawing prints to Consultant for review. Make necessary revisions to drawings as per Consultant's comments, to satisfaction of Consultant.
- .6 Use final reviewed "as-built" drawing set to provide CAD files of drawings thus forming true "as-built" set of Contract Drawings. Identify set as "Project Record Copy". Load digital copies of final reviewed by Consultant as-built drawings onto USB type flash drive. Provide 2 complete sets of "as-built" drawings on separate USBs. Submit "as-built" sets of white prints and USBs to Consultant. Save drawings as AutoCAD files and in pdf format and such that each drawing is not x-referenced but as complete drawing.
- .7 Submitted drawings are to be of same quality as original Contract Drawings. CAD drawing files are to be compatible with software release version reviewed with Consultant.
- .8 Alternatively, arrange for and make payment to Consultant of respective trade of work to produce record CAD drawings of as-built work from as built white prints. Include cost of \$100 plus GST, per drawing.
- .9 Unless otherwise noted in Divisions 00 or 01, failure to maintain accurate record drawings will incur additional 5% holdback on progress claims until drawings are brought up to date to satisfaction of Owner and reviewed with Consultant.
- .10 For projects with phased turnover of project (refer to Division 01), review with Consultant completeness of as-built drawings prior to turn over of an area. Copies of hand drawn interim as-built drawings to be made available to Owner's maintenance personnel.

Mechanical Work General Instructions

- .11 Retain and pay for services of a land surveyor registered in Place of the Work to measure, verify, and record size, location, invert elevation and pitch of buried piping services, and, when complete, to produce a signed and sealed AutoCAD disc (of release version reviewed with Consultant) of survey work which is to be submitted to Consultant. Transfer survey work to as-built drawings.
- .12 Requirements regarding medical gas piping system as-built record drawings are as follows:
 - .1 prepare a separate set of site record red line white print drawings on a day-to-day basis, and provide a separate record CAD disc and a set of record white prints in accordance with requirements of CAN/CSA Z7396.1.
 - .2 obtain from Owner, existing medical gas piping record drawings and, on a day-to-day basis, record alteration work and new work, including location of concealed piping, and, if a drawing disc is available, update disc using compatible CAD software, in accordance with requirements of CAN/CSA Z7396.1.
 - .3 obtain from Owner, existing medical gas system record drawings (and CAD disc if applicable), and, on a day-to-day basis, record medical gas system work, incorporating existing work which is to remain, and provide a separate record CAD disc and white prints in accordance with requirements of CAN/CSA Z7396.1.

1.32 Operating and Maintenance Manuals

- .1 For each item of equipment for which a shop drawing is required (except for simple equipment), supply minimum 3, project specific, indexed copies of equipment manufacturers' operating and maintenance (O & M) manuals. Review exact quantity of manuals with Consultant. Consolidate each copy of data in an identified hard cover three "D" ring binder. Each binder to include:
 - .1 front cover: project name; wording – "Mechanical Systems Operating and Maintenance Manual"; and date;
 - .2 introduction sheet listing Consultant, Contractor, and Subcontractor names, street addresses, telephone and fax numbers, and e-mail addresses;
 - .3 equipment manufacturer's authorized contact person name, telephone number and company website;
 - .4 Table of Contents sheet, and corresponding index tab sheets;
 - .5 copy of each "REVIEWED" or clean, updated "REVIEWED AS NOTED" shop drawing or product data sheet, with manufacturer's/supplier's name, telephone and fax numbers, email address, company website address, and email address for local source of parts and service; when shop drawings are returned marked "Reviewed As Noted" with revisions marked on shop drawing copies, they are to be revised by equipment supplier to incorporate comments marked on "Reviewed" shop drawings and a clean updated copy is to be included in operating and maintenance manuals;
 - .6 operating data as follows:
 - .1 pressure test reports, and certificates issued by governing authorities;
 - .2 description of each system and its controls;

Mechanical Work General Instructions

- .3 control schematics for equipment/systems including building environmental controls;
- .4 wiring and connection diagrams;
- .5 if applicable, BAS architecture and required operating data;
- .6 description of operation of each system at various loads together with reset schedules and seasonal variances;
- .7 operation instruction for each system and each component;
- .8 description of actions to be taken in event of emergencies and/or equipment failure;
- .9 valve tag schedule, and flow diagrams to indicate valve locations.
- .7 maintenance data as follows:
 - .1 operation and trouble-shooting instructions for each item of equipment and each system;
 - .2 schedules of tasks, frequency, tools required, and estimated task time;
 - .3 recommended maintenance practices and precautions including warnings of any maintenance practice that will damage or disfigure equipment/systems;
 - .4 complete parts lists with numbers.
- .8 performance data as follows:
 - .1 equipment and system start-up data sheets;
 - .2 equipment performance verification test results, and final commissioning report;
 - .3 final testing, adjusting and balancing reports.
- .9 copies of warranties;
- .10 items requested specifically in Section Articles.
- .2 Generally, binders are not to exceed 75 mm (3") thick and not to be more than 2/3 full.
- .3 Operating and maintenance instructions are to relate to job specific equipment supplied under this project and related to Owner's building. Language used in manuals is to contain simple practical operating terms and language easy for in-house maintenance staff to understand how to operate and maintain each system.
- .4 Before applying for a Certificate of Substantial Performance of the Work, assemble one copy of O&M Manual and submit to Consultant for review prior to assembling remaining copies. Incorporate Consultant's comments into final submission.
- .5 Provide 2 digital copies of contents of operating and maintenance manuals and load onto separate USB type flash drives and submit to Consultant. Prepare digital copies using version of Adobe Acrobat Portable Document Format or equal as reviewed with Consultant and enhanced with bookmarks and internal document links.

1.33 Project Closeout Submittals

- .1 Prior to application for Substantial Performance of the Work, submit required items and documentation specified, including following:

Mechanical Work General Instructions

- .1 O & M Manuals;
 - .2 as-built record drawings and associated data;
 - .3 extended warranties for equipment as specified;
 - .4 operating test certificates, i.e. Sprinkler Test Certificate;
 - .5 final commissioning report and TAB report;
 - .6 identified keys for equipment and/or panels for which keys are required, and other items required to be submitted;
 - .7 other data or products specified.
- .2 Refer to additional requirements in Division 01.

1.34 Instructions to Owner

- .1 Refer to equipment and system operational and maintenance training requirements specified in Division 01.
- .2 Train Owner's designated personnel in aspects of operation and maintenance of equipment and systems as specified. Demonstrations and training are to be performed by qualified technicians employed by equipment/system manufacturer/supplier. Supply hard copies of training materials to each attendee.
- .3 Unless where specified otherwise in trade Sections, minimum requirements are for manufacturer/suppliers of each system and major equipment, to provide minimum two separate sessions each consisting of minimum 4 hours on site or in factory training (at Owner's choice), of Owner's designated personnel (for up to 6 people each session), on operation and maintenance procedures of system.
- .4 For each item of equipment and for each system for which training is specified, prepare training modules as specified below. Use O&M Manuals during training sessions. Training modules include but are not limited to:
 - .1 Operational Requirements and Criteria: Equipment function, stopping and starting, safeties, operating standards, operating characteristics, performance curves, and limitations;
 - .2 Troubleshooting: Diagnostic instructions, test and inspection procedures;
 - .3 Documentation: Equipment/system warranties, and manufacturer's/supplier's parts and service facilities, telephone numbers, email addresses, and the like;
 - .4 Maintenance: Inspection instructions, types of cleaning agents to be used as well as cleaning Methods, preventive maintenance procedures, and use of any special tools;
 - .5 Repairs: Diagnostic instructions, disassembly, component removal and repair instructions, instructions for identifying parts and components, and review of any spare parts inventory.
- .5 Before instructing Owner's designated personnel, submit to Consultant for review preliminary copy of training manual and proposed schedule of demonstration and training dates and times. Incorporate Consultant's comments in final copy.

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- .6 Obtain in writing from Consultant list of Owner's representatives to receive instructions. Submit to Consultant prior to application for Certificate of Substantial Performance of the Work, complete list of systems for which instructions were given, stating for each system:
 - .1 date instructions were given to Owner's staff;
 - .2 duration of instruction;
 - .3 names of persons instructed;
 - .4 other parties present (manufacturer's representative, consultants, etc.).
- .7 Obtain signatures of Owner's staff to verify they properly understood system installation, operation and maintenance requirements, and have received operating and maintenance instruction manuals and "as-built" record drawings.
- .8 Submit to Consultant, copy of electronic version of training materials loaded on USB flash drive. Include in operating and maintenance manuals submission.
- .9 Provide digital video disc (DVD) recording of operating and instructions training for following systems:
 - .1 building automation system.
- .10 Provide a custom video in DVD format that details on site systems and equipment operations and includes following:
 - .1 professional videographer on site to capture training session; use wireless lavalier microphone to capture crystal clear audio of trainer in association with video footage; edit video to remove unnecessary footage;
 - .2 DVD to include custom site specific system/equipment screens that outline key information about system/equipment and devices used on site only;
 - .3 DVD to also include custom site specific video that details programming procedures in conjunction with a voiceover from on-site technician;
 - .4 DVD created with a main menu screen and authored with chapters to allow operator to access specific areas of training instantly.
- .11 Supply minimum quantity of 3 copies of DVDs for each system/equipment.

1.35 Final Inspection

- .1 Submit to Consultant, written request for final inspection of systems. Include written certification that:
 - .1 deficiencies noted during job inspections have been completed;
 - .2 field quality control procedures have been completed;
 - .3 systems have been tested and verified, balanced and adjusted, and are ready for operation;
 - .4 maintenance and operating data have been completed and submitted to, reviewed with Consultant and accepted by Owner;
 - .5 tags and nameplates are in place and equipment identifications have been completed;

Mechanical Work General Instructions

- .6 clean-up is complete;
- .7 spare parts and replacement parts specified have been provided, as confirmed by Owner and reviewed with Consultant;
- .8 as-built and record drawings have been completed and submitted to and reviewed with Consultant and accepted by Owner;
- .9 Owner's staff has been instructed in operation and maintenance of systems;
- .10 commissioning procedures have been completed.

PART 2 - PRODUCTS

2.1 NOT USED

PART 3 - EXECUTION

3.1 NOT USED

END OF SECTION

PART 1 - GENERAL

1.1 Reference

- .1 Division 00 and Division 01 apply to and are a part of each Mechanical Division Section.

1.2 Application

- .1 This Section specifies products, criteria and characteristics, and methods and execution that are common to one or more Sections of Mechanical Divisions. It is intended as a supplement to each Section and is to be read accordingly.
- .2 Advise product vendors of requirements of this Section.

1.3 Submittals

- .1 Submit shop drawings/product data sheets for:
 - .1 pressure gauges and thermometers;
 - .2 electric motors (submit with equipment they are associated with).
- .2 Submit weight loads for selected equipment (upon request).
- .3 Submit copy of architectural reflected ceiling plan drawings and elevation drawings to indicate proposed access door locations.
- .4 Submit sample of each proposed type of access door if supplied under work of this Division.
- .5 Submit samples of materials and any other items as specified in Sections of Mechanical Divisions.
- .6 Submit list of equipment identification nameplates indicating proposed wording and sizes.
- .7 Submit list of pipe and duct identification colour coding and wording.
- .8 Submit proposed valve tag chart and a list of proposed valve tag numbering and identification wording.
- .9 Submit drawings indicating size and location of required sleeves, recesses and formed openings in poured or precast concrete work.
- .10 As specified in Part 2 of this Section, submit spare belt set, tagged and identified, for each belt driven piece of equipment.
- .11 Submit any other submittals specified in this Section or other Sections of Mechanical Divisions.

1.4 Equipment Withstand Ratings

- .1 Coordinate with Electrical Divisions Contractor with regards to obtaining calculations of short circuit current ratings (SCCR) and available fault currents at each level of electrical distribution system that serves major mechanical equipment.
- .2 Select mechanical equipment able to withstand and labeled with required appropriate SCCR sufficient for voltage employed and fault current at terminals of equipment.
- .3 Where SCCR are not identified, assume for pricing minimum 35 kA for small equipment and 65 kA for larger HVAC units.

- .4 Review with Consultant and Division 26 Electrical Contractor, prior to ordering equipment, and identify required SCCR on shop drawings.

1.5 Pre-Tendered Equipment

- .1 Refer to Appendix for complete information regarding scope of work for pre-tendered equipment. Equipment have been pre-tendered, ordered, and paid for by Owner. Associated work to be included as part of Work of Mechanical Division of this Project, that is to include for, but not be limited to, provision of following:
 - .1 coordination with respective equipment manufacturers with regards to delivery, unloading and acceptance on site;
 - .2 inspection upon delivery and acceptance;
 - .3 unloading, transporting and moving/hoisting into installation position;
 - .4 installation, connection, testing, and certification.
- .2 Take over order and coordinate with various manufacturers/suppliers of pre-ordered equipment and associated Work. During inspection of pre-ordered equipment and associated components at site, report deficiencies to respective supplier and to Owner and be responsible for resolving such deficiencies directly with respective supplier(s).
- .3 Be available for and attend factory testing at supplier's offices of pre-ordered equipment and associated Work, as requested by Consultant.
- .4 Coordinate final installation requirements with manufacturers/suppliers of pre-ordered equipment and associated Work.
- .5 For reference purposes, copy of shop drawing may be obtained from Consultant after order has been made.
- .6 Review installation schematics and diagrams, control system schematics, and wiring diagrams supplied by manufacturers/suppliers of pre-ordered equipment and associated Work. Coordinate interconnections with related various building systems.
- .7 Refer to respective equipment Section - Part 3 for additional installation requirements.
- .8 Refer also to Appendix for further details and requirements of pre-tendered equipment. Be responsible for review of issued documents and request further information from Consultant, if required. Include and incorporate required provisions and associated costs required for a complete installation.
- .9 Install equipment in accordance with drawing notes, specifications, and manufacturer's instructions and to comply with Owner's on-site standards and regulations.

PART 2 - PRODUCTS

2.1 Pipe Sleeves

- .1 Galvanized Sheet Steel: Minimum #16 gauge galvanized steel with an integral flange at one end to secure sleeve to formwork construction.
- .2 Polyethylene: Factory fabricated, flanged, high density polyethylene sleeves with reinforced nail bosses.

- .3 Waterproof Galvanized Steel Pipe: Schedule 40 mild galvanized steel pipe with a welded-on square steel anchor and water stop plate at sleeve midpoint.
- .4 Galvanized Steel or Cast Iron Pipe: Schedule 40 mild galvanized steel, or Class 4000 cast iron.

2.2 Firestopping and Smoke Seal Materials

- .1 Firestopping and smoke seal system materials for mechanical penetrations through fire rated construction are specified in Division 07 and work will be included as part of work of Division 07.
- .2 Firestopping and smoke seal system materials for mechanical penetrations through fire rated construction are specified in Section entitled Firestopping and Smoke Seal Systems and work is to be included as part of mechanical work.

2.3 Waterproofing Seal Materials

- .1 Modular, mechanical seal assemblies consisting of interlocking synthetic rubber links shaped to continuously fill annular space between pipe and pipe sleeve or wall opening, assembled with stainless steel bolts and pressure plates and designed so when bolts are tightened the links expand to seal the opening watertight. Select seal assemblies to suit pipe size and sleeve size or wall opening size.
- .2 Acceptable products are:
 - .1 Thunderline Corp. (Power Plant Supply Co.) "LINK SEAL" Model S-316;
 - .2 The Metraflex Co. "MetraSeal" type ES.
- .3 Special hangers and supports for various applications as follows:
 - .1 vibration isolated riser supports – black steel riser clamps as specified above, complete with neoprene–steel–neoprene sandwich type vibration isolation pads between clamp and floor;
 - .2 for groups of pipes having same slope – MSS Type 32 welded steel brackets, Anvil Fig. 46 universal trapeze assemblies, or Unistrut or approved equal support assemblies, all with U-bolts, clamps, etc., to secure pipes in place;
 - .3 for sections of piping connected to vibration isolated equipment – hangers and supports as specified above but complete with MSS Type 48 spring cushions;
 - .4 for glass drain and vent piping – special padded hangers supplied by pipe supplier;
 - .5 for plastic piping – generally as specified above but in accordance with pipe manufacturer's recommendations;
 - .6 for fire protection piping – generally as above but ULC listed and/or FM approved, and in accordance with Chapter requirements of NFPA Standard applicable to piping system;
 - .7 for bare horizontal copper piping – generally as above but factory vinyl coated to prevent direct copper/steel contact;
 - .8 for bare copper vertical piping – corrosion resistant ferrous clamps with flexible rubber gasket type material (not tape) to isolate pipe from clamp;

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- .9 insulation protection shields to and including 40 mm (1-½") dia. – MSS Type 40 galvanized steel shields with ribs to keep shield centred on hanger.
- .4 Hanger rods are to be electro-galvanized carbon steel (unless otherwise specified), round, threaded, to ASTM A36, complete with captive machine nuts with washers at hangers, sized to suit loading in accordance with Table 3 in MSS SP-58, but minimum 9.5 mm (3/8") diameter.
- .5 Acceptable manufacturers are:
 - .1 E. Myatt & Co. Inc.;
 - .2 Anvil International Inc.;
 - .3 Empire Industries Inc.;
 - .4 Hunt Manufacturing Ltd.;
 - .5 Unistrut Canada Ltd.;
 - .6 Nibco Inc. "Tolco";
 - .7 Taylor Pipe Supports.

2.4 Access Doors

- .1 Access doors to be provided under work of Division 08 by General Trades Contractor.
- .2 Coordinate with Mechanical Contractor and General Trades Contractor to ensure access doors on project are provided by a single manufacturer, installed as part of work of General Trades Contractor and work involving both mechanical and electrical services, where possible, be accessible from common access door. Coordinate work to ensure same common location access doors are not supplied by more than one Division.
- .3 Size access doors to suit the concealed work for which they are supplied, and wherever possible they are to be of standard size for all applications, but minimum 300 mm x 300 mm (12" x 12") for hand entry and 600 mm x 600 mm (24" x 24") for body entry.
- .4 Access doors in fire rated construction are to be ULC listed and labelled and of a rating to maintain fire separation integrity.
- .5 Identify on reflected ceiling plans and wall elevation drawings, coordinated locations of proposed access door locations and submit to Consultant for review.

2.5 Pressure Gauges and Thermometers

- .1 Pressure gauges as follows:
 - .1 adjustable, glycerine filled, 100 mm or 115 mm (4" or 4-½") diameter and each accurate to within 1% of scale range;
 - .2 type 304 stainless steel case with relief valve and polished stainless steel bayonet;
 - .3 stainless steel rotary movement with stainless steel bushings and socket;
 - .4 clear acrylic window;
 - .5 dual scale white dial with a scale range such that working pressure of system is at approximate mid-point of scale;

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- .6 black pointer.
- .2 Pressure gauge accessories and additional requirements as follows:
 - .1 bronze ball type shut-off valve is to be provided in piping to each pressure gauge;
 - .2 each pressure gauge for piping and equipment with normal everyday flow is to be equipped with a brass pressure snubber;
 - .3 pressure gauges in fire protection piping must be ULC listed and labelled;
 - .4 pressure gauges in medical gas piping systems are to conform to CSA Z7396.1 and are to be identified with name of service it is provided for as well as "USE NO OIL".
- .3 Thermometers as follows:
 - .1 round, 125 mm (5") diameter, adjustable (90°) angle bimetal dial type thermometers, each accurate to within 1% of full scale;
 - .2 hermetically sealed stainless steel case with stainless steel ring;
 - .3 dampened bimetal coil;
 - .4 calibration adjustment screw;
 - .5 white aluminum dual scale dial with black and blue markings and a range such that working temperature of system is approximate mid-point of the scale;
 - .6 black aluminum pointer;
 - .7 double strength glass window;
 - .8 12 mm (½") NPT connection with 6.4 mm (¼") diameter stainless steel stem;
 - .9 suitable thermowell.
- .4 Acceptable manufacturers are:
 - .1 H.O. Trerice Co.;
 - .2 Weiss Instruments;
 - .3 Ashcroft.

2.6 Equipment Belt Drives

- .1 ANSI/RMA Standard V-belt type rated at minimum 1.5 times motor nameplate rating, and in accordance with following requirements:
 - .1 belts are to be reinforced cord and rubber, and multiple belts are to be matched sets;
 - .2 sheaves are to be cast iron or steel, secured to shafts with removable keys unless otherwise specified, standard adjustable pitch ($\pm 10\%$ range) for motors under 10 HP, fixed pitch type with split tapered bushing and keyway for motors 10 HP and larger, and, if required, replaced as part of mechanical work to suit system air/water quantity testing and balancing work;
 - .3 motor slide rail adjustment plates are to allow for centre line adjustment.
- .2 Supply a spare belt set (tagged and identified) for each belt drive as reviewed with Consultant, and turn over to Owner upon Substantial Performance of the Work.

2.7 Equipment Drive Guards and Accessories

- .1 For V-Belt Drives: Removable, 4-sided, fully enclosed, galvanized sheet steel guards to OHSA standards, cleaned, factory primed and painted with yellow equipment enamel, complete with a 2-piece full length hinged front panel to permit belt maintenance or replacement without removing guard, and 40 mm (1-½") diameter tachometer openings at each shaft location.
- .2 For Flexible Couplings: Removable "U" shaped galvanized steel guards to OHSA Standards with a 2.3 mm (3/32") thick frame and expanded mesh face.
- .3 For Unprotected Fan Inlets and Outlets: Unless otherwise specified, removable 20 mm (¾") galvanized steel wire mesh with galvanized steel frames, all to OHSA Standards.

2.8 Electric Motors

- .1 Unless otherwise specified, motors are to conform to NEMA Standard MG1, applicable IEEE Standards, and applicable CSA C22.2 Standards, and are to meet NEMA standards for maximum sound level ratings under full load. Confirm motor voltages prior to ordering.
- .2 Vertically mounted and submersible motors are to be purposely designed for mounting in this attitude.
- .3 Efficiency of 1-phase motors to 1 HP is to be in accordance with CAN/CSA C747. Efficiency of 3-phase motors 1 HP and larger is to be in accordance with CAN/CSA C390 or IEEE 112B.
- .4 Unless otherwise specified, 1-phase motors smaller than ½ HP are to be 115 volt, continuous duty capacitor start type with an NEMA 48 or 56 frame size, solid base, heavy-gauge steel shell with solid die-cast end shields, dynamically balanced die-cast rotor, integral automatic reset thermal overload protection, Class "B" insulation, and a 1.15 service factor at 40°C (105°F) ambient temperature.
- .5 Explosion-proof 1-phase motors are to be totally enclosed, fan cooled, 115 volt continuous duty capacitor start type in accordance with CSA C22.2 No. 145, as specified for standard 1-phase motors but suitable for use in Class 1 Group D hazardous locations and complete with a rolled steel shell and a 1.0 service factor at 40°C (105°F) ambient temperature.
- .6 Unless otherwise specified, motors ½ HP and larger are to be totally enclosed, fan cooled, 3-phase, T-frame, squirrel cage continuous duty induction motors suitable for voltages indicated on Drawings, NEMA Design "B" for normal starting torque or Design "C" for high starting torque as required by the application, each complete with Class "B" insulation, a 1.15 service factor at 40°C ambient temperature, grease lubricated open ball bearings with grease fittings to permit re-lubrication without dismantling motor, a cast iron frame with cast iron feet where required, cast iron end bracket and precision machined bearing fit, and balanced carbon steel shaft assembly with die-cast aluminum rotor windings.
- .7 Explosion-proof 3-phase motors are to be totally enclosed fan cooled motors in accordance with CSA C22.2 No. 145, generally as specified above for standard 3-phase motors but suitable for use in Class 1 Group D hazardous locations and with a 1.0 service factor at 40°C (105°F) ambient temperature.
- .8 Motor(s) for 2-speed fan(s) are to be as above but 2-speed double winding type.
- .9 Unless otherwise indicated, motors 30 HP and larger are to be complete with a heat sensing PTC thermistor in the end turn of stator winding for each phase and connected in series inside motor with 2 marked leads brought out to motor conduit box.

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- .10 Motors for equipment with variable frequency drives are to be generally as specified above but inverter duty type to NEMA Standard MG-1 Part 31, quantified by CSA for operation from a variable frequency drive of type specified, and complete with Class "H" insulation. Motors are to be equipped with AEGIS, or approved equal, shaft grounding ring system to protect bearings from damage by diverting harmful shaft voltages and bearing currents to ground.
- .11 Motors for equipment which is scheduled or specified with a corrosion resistant coating or constructed from corrosion resistant materials are to be factory coated with a primer and epoxy paint finish.
- .12 Acceptable manufacturers are:
 - .1 TECO-Westinghouse Motors (Canada) Inc.;
 - .2 Canadian General Electric;
 - .3 Baldor Electric Co.;
 - .4 U.S. Electrical Motors;
 - .5 WEG Electric Corp.;
 - .6 Marathon Electric;
 - .7 Toshiba Corp.;
 - .8 Leeson Canada.

2.9 Motor Starters and Accessories

- .1 Motor starters to be capable of starting associated motors under imposed loads. Confirm starter voltage matches motor prior to ordering.
- .2 Unless otherwise specified, starters for 1-phase motors are to be 115 volt, thermal overload protected manual starting switches with neon pilot light, surface or recessed enclosure to suit application, and, where automatic operation is required, separate H-O-A switch in enclosure to match starter enclosure.
- .3 Unless otherwise specified, starters for 3-phase motors less than 50 HP are to be combination "quick-make" and "quick-break" fused disconnects and full voltage non-reversing across-the-line starters, each complete with overload relay per phase, enclosure to suit application, and accessories in accordance with motor starter schedule.
- .4 Unless otherwise specified, starters for 3-phase motors 50 HP to 150 HP are to be reduced voltage, non-reversing, auto-transformer type starters complete with one overload relay per phase, enclosure to suit application, and accessories in accordance with motor starter schedule.
- .5 Unless otherwise specified, starters for 3-phase motors 150 HP and larger are to be reduced voltage, non-reversing, closed transition "wye-delta" starters complete with one overload relay per phase, enclosure to suit application, and accessories in accordance with motor starter schedule.
- .6 Starters for 2-speed double winding motors are to be generally as specified above but suitable for motor and equipped with 45 second time delay to permit equipment to coast down to low speed before it is operated at low speed.

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- .7 Starters for 2-speed single winding motors are to be generally as specified above but suitable for motor and equipped with 45 second time delay to permit equipment to coast down to low speed before it is operated at low speed.
- .8 Starters for reversible motors for cooling towers are to be generally as specified above but suitable for motor and equipped with 45 second time delay to allow fan(s) to coast down to stop before being operated in reverse rotation.
- .9 Unless otherwise specified, motor starter enclosures are to be in accordance with following NEMA ratings:
 - .1 enclosures located in sprinklered areas – Type 2;
 - .2 enclosures exposed to the elements – Type 3R, constructed of stainless steel;
 - .3 enclosures inside the building in wet areas – Type 3R, constructed of stainless steel;
 - .4 enclosures in explosion rated area – Type 7 with exact requirements to suit the area and application;
 - .5 enclosures except as noted above – Type 1;
 - .6 enclosures located in finished areas – as above but recess type with brushed stainless steel faceplate.
- .10 Motor control centres are to be multi-unit, 2.28 m (9') high, NEMA Class 1, type "B", factory assembled, dead front, floor mounted, free-standing motor control centre with tin plated copper bus and NEMA Type 1 or Type 2 enclosure as for loose starters specified above. Each motor control centre is to be complete with starters as specified above, load and control wiring terminal boards, and required facilities for line and load side power wiring connections.
- .11 Disconnect switches for motor control centres are to be heavy-duty, CSA certified, front operated switches as per motor starter schedule, each complete with a handle suitable for padlocking in "off" position and arranged so that door cannot be opened with handle in "on" position and an NEMA enclosure as specified for loose starters. Fusible units are to be complete with fuse clips to suit fuse types specified below.
- .12 Fuses are to be, unless otherwise scheduled or specified, English Electric Ltd. HRC fuses, Form I Class "J" for constant running equipment and Form II Class "C" for equipment that cycles on and off.
- .13 Acceptable manufacturers are:
 - .1 Rockwell Automation Inc. - Allen-Bradley;
 - .2 Eaton;
 - .3 Siemens Canada;
 - .4 Schneider Electric.

2.10 Sprinkler Protection

- .1 Provide drip shields for protection of surface mounted equipment enclosures from water spray and dripping of liquids. Features of shields include:
 - .1 factory constructed by respective equipment manufacturers;

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- .2 constructed from non-combustible materials (sheet steel);
 - .3 enamel painted to match equipment;
 - .4 surfaces and edges filled/sanded smooth prior to painting;
 - .5 supported from equipment with structural steel rods/metal framing or other method approved by Consultant;
 - .6 structural support finish painted to match shield.
- .2 Include with equipment shop drawings, detailed dimensions of drip shields and methods of supporting.
 - .3 Equipment with top cable/conduit entries to include additional sealing of entries with gasketing and/or waterproof sealant to prevent water from entering enclosure.
 - .4 Design ventilation louvers such that live components are not exposed to water spray and dripping liquids.
 - .5 Above requirements are additional minimum "sprinkler protection" (or sprinkler proof) standards for equipment specified as NEMA 1, 2 or 12.
 - .6 Obtain CSA approval where required by local governing authorities.

2.11 Mechanical Work Identification Materials

- .1 Equipment nameplates are to be minimum 1.6 mm (1/16") thick 2-ply laminated coloured plastic plates, minimum 12 mm x 50 mm (1/2" x 2") for smaller items such as damper motors and control valves, minimum 25 mm x 65 mm (1" x 2-1/2") for equipment, and minimum 50 mm x 100 mm (2" x 4") for control panels and similar items. Additional requirements are as follows:
 - .1 unless otherwise specified or required, each nameplate is to be white, complete with bevelled edges and black engraved wording to completely identify equipment and its use with no abbreviations;
 - .2 wording is generally to be as per drawings, i.e. Fan EF-1, and is to include equipment service and building area/zone served, but must be reviewed with Consultant prior to engraving;
 - .3 supply stainless steel screws for securing nameplates in place;
 - .4 nameplates for equipment suspended above floor level or generally not within easy viewing from floor level are to be increased in size so as to be easily readable from floor level.
- .2 Valve tags are to be coloured, 40 mm (1-1/2") square, 2-ply laminated plastic with bevelled edges, red-white, green-white, yellow-black, etc., to match piping identification colour, each complete with a 3.2 mm (1/8") diameter by 100 mm (4") long brass plated steel bead chain, and four lines of engraved maximum size identification wording, i.e.:

VALVE V12
200 mm (8")
CHILL. WATER
NORMALLY OPEN

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- .3 Standard pipe identification to be Smillie McAdams Summerlin Ltd., Brady or Primark Manufacturing Inc. vinyl plastic with indoor/outdoor type vinyl ink lettering and directional arrows, as follows:
- .1 for pipe less than or equal to 150 mm (6") diameter, coiled type snap-on markers of a length to wrap completely around pipe or pipe insulation;
 - .2 for pipe larger than 150 mm (6") diameter, saddle type strap-on markers with 2 opposite identification locations and complete with nylon cable ties.
- .4 Identification wording and colours for pipe identification materials are to be as follows:

PIPE SERVICE	IDENTIFICATION COLOUR	LEGEND
domestic cold water	green	DOM. COLD WATER
domestic hot water supply	green	DOM. HW SUPPLY
domestic hot water recirculation	green	DOM. HW RECIRC.
tempered domestic water	green	TEMP. DOM. WATER
chilled drinking water	green	CH. DRINK WTR.
storm drainage	green	STORM
sanitary drainage	green	SAN.
plumbing vent	green	SAN. VENT
acid sanitary drainage	yellow	ACID DRAIN
acid drainage vent	yellow	ACID VENT
fire protection standpipe	red	F.P. STANDPIPE
fire protection sprinklers	red	F.P. SPRINKLER
natural gas	to Code	to Code, c/w pressure
natural gas vent	to Code	to Code
propane gas	to Code	to Code, c/w pressure
propane gas vent	to Code	to Code
fuel oil supply	yellow	FUEL OIL SUPPLY
fuel oil return	yellow	FUEL OIL RETURN
fuel oil vent	yellow	FUEL OIL VENT
heating water supply	yellow	HTG. WTR. SUPPLY
heating water return	yellow	HTG. WTR. RETURN
heating water drain	yellow	HTG. WTR. DRAIN
glycol heating supply	yellow	GLY. HTG. SUPPLY

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PIPE SERVICE	IDENTIFICATION COLOUR	LEGEND
glycol heating return	yellow	GLY. HTG. RETURN
glycol heating drain	yellow	GLY. HTG. DRAIN
glycol heat reclaim return	yellow	GLY. HTG. RECLAIM R.
glycol heat reclaim supply	yellow	GLY. HTG. RECLAIM S.
heat pump geothermal loop – source side supply	green	GEO. LOOP SOURCE SUPPLY
heat pump geothermal loop – source side return	green	GEO. LOOP SOURCE RETURN
heat pump geothermal loop – load side supply	green	GEO. LOOP LOAD SUPPLY
Heat pump geothermal loop – load side return	green	GEO. LOOP LOAD RETURN
condenser water supply	green	COND. WTR. SUPPLY
condenser water return	green	COND. WTR. RETURN
chilled water supply	green	CH. WTR. SUPPLY
chilled water return	green	CH. WTR. RETURN
chilled water drain	green	CH. WTR. DRAIN
low pressure steam	yellow	...kPa STEAM
medium pressure steam	yellow	...kPa STEAM
high pressure steam	yellow	...kPa STEAM
low pressure condensate	yellow	L.P. CONDENSATE
medium pressure condensate	yellow	M.P. CONDENSATE
high pressure condensate	yellow	H.P. CONDENSATE
pumped condensate	yellow	PUMPED CONDENSATE
steam vent	yellow	STEAM VENT
boiler feedwater	yellow	BLR. FEEDWATER
boiler blowdown	yellow	BLR. BLOW-OFF
refrigerant suction	yellow	REFRIG. SUCTION
refrigerant liquid	yellow	REFRIG. LIQUID

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PIPE SERVICE	IDENTIFICATION COLOUR	LEGEND
refrigerant hot gas	yellow	REFRIG. HOT GAS
diesel engine exhaust	yellow	ENGINE EXHAUST
gasoline	yellow	GASOLINE
distilled water	green	DISTILL. WATER
demineralized water	green	DEMIN. WATER
compressed air (< 700 kPa)	green	...kPa COMP. AIR
compressed air (>700 kPa)	yellow	...kPa COMP. AIR
control air	green	CONTROL AIR

- .5 Colours for pipe identification legends and directional arrows are to be as follows:

IDENTIFICATION COLOUR	LEGEND & ARROW COLOUR
yellow	black
green	white
red	white

- .6 Medical gas piping identification materials and requirements are specified in Section entitled Medical Gas Piping Systems.
- .7 Duct identification is to be custom made Mylar stencils with 50 mm (2") high lettering to accurately describe duct service, i.e. "AHU-1 SUPPLY", complete with a directional arrow, and coloured ink with ink pads and roller applicators. Ink colour is generally to be black but must contrast with lettering background.

2.12 Flexible Connectors

- .1 Double wall stainless steel flexible connectors for piping connections to vibration isolated equipment, each selected by manufacturer to suit the application. Shop drawings or product data sheets must indicate construction and performance requirements that suit the application. Acceptable manufacturers are:
- .1 Hyspan Precision Products Inc.;
 - .2 Senior Flexonics Ltd.;
 - .3 The Metraflex Co.

PART 3 - EXECUTION

3.1 General Piping and Ductwork Installation Requirements

- .1 Unless otherwise specified, locate and arrange horizontal pipes and ducts above or at ceiling on floors, arranged so that under consideration of all other work in area, maximum ceiling height and/or usable space is maintained. If required to maintain ceiling heights, reroute and/or resize ductwork, as reviewed with Consultant and with Owner approval.

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- .2 Unless otherwise specified, install work concealed in finished spaces, and concealed to degree possible in partially finished and unfinished spaces. Refer to and examine Architectural drawings and room finish schedules to determine finished, partially finished, and unfinished areas. Walls which are painted are considered finished.
- .3 Install pipes and ducts parallel to building lines and to each other.
- .4 Neatly group and arrange exposed work.
- .5 Locate work to permit easy access for service or maintenance as required and/or applicable. Locate valves, dampers and any other equipment which will or may need maintenance or repairs and which are to be installed in accessible construction so as to be easily accessible from access doors. Where valves, dampers and similar piping or ductwork accessories occur in vertical services in shafts, pipe spaces or partitions, locate accessories at floor level.
- .6 Make connections between pipes of different materials using adapters suitable for application. Provide cast brass dielectric type adapters/unions at connections between ferrous and copper pipe.
- .7 Comply with equipment and material manufacturer's installation instructions unless otherwise specified herein or on drawings, and unless such instructions contradict governing codes and regulations.
- .8 Carefully clean ducts, pipe and fittings prior to installation. Temporarily cap or plug ends of pipe, ducts and equipment which are open and exposed during construction.
- .9 Install piping and ductwork which are to be insulated, to have sufficient clearance to permit insulation and finish to be applied continuously and unbroken around pipe or duct, except for ductwork at fire barriers, terminate insulation at each side of duct fire damper.
- .10 Inspect surfaces and structure prepared by other trades before performing work. Verify surfaces or structure to receive work has no defects or discrepancies which could result in poor application or cause latent defects in installation and workmanship. Report defects in writing to Consultant. Installation of work will constitute acceptance of such surfaces as being satisfactory.
- .11 Any ferrous piping that exhibits in excess of 5% surface rust, either inside or outside or both, is to be wire brush cleaned to bare metal and coated with suitable primer. Steel pipe, fittings and accessories are to be free of corrosion and dirt when work is complete or prior to being concealed from view. Where dirt is evident, clean piping prior to being concealed.
- .12 Provide continuous galvanized sheet metal drip pan under drain, water and water solution piping extending through rooms with electrical equipment such as electrical, elevator equipment and transformer rooms, and other spaces provided primarily for the installation of electrical equipment. Provide drip pans with drain pipe connection and extend drain piping to closest drain.
- .13 For factory applied finishes, repaint or refinish surfaces damaged during shipment and installation. Quality of repair work is to match original finish. This requirement also applies to galvanized finishes.
- .14 Where mechanical work is located in high humidity areas where ferrous metal products will be subject to corrosion and protection for such products is not specified, provide finishes on products to protect against corrosion or provide products which will not corrode in the environment, i.e. aluminium ductwork, copper or stainless steel pipe, etc.

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- .15 Provide screwed unions or flanges in piping connections to equipment and in regular intervals in long (in excess of 12 m [40']) piping runs to permit removal of sections of piping.
- .16 Unless otherwise specified and except where space limitations do not permit, piping elbows are to be long radius. Eccentric reducers are to be installed with straight side at top of piping.
- .17 Joints in medical gas system piping are to be silver brazed in accordance with requirements of CAN/CSA Z7396.1.
- .18 Install mechanical joint fittings and couplings in accordance with manufacturer's instructions.
- .19 Grooves are to be rolled. Make arrangements with coupling and fitting manufacturer for shop and/or site instructions and demonstrations as required, and adhere to manufacturer's instructions with respect to pipe grooving, support, type of gasket required, anchoring and guiding grooved piping system.
- .20 If pressure crimped couplings and fittings are used, ensure gaskets are fully compatible with piping fluid, and valves and piping accessories are suitable. Use only fitting manufacturer supplied crimping equipment. Comply with manufacturer's latest published specification, instructions, and recommendations with respect to pipe, coupling, and fitting preparation and installation, and support, anchoring and guiding of piping system.
- .21 Solvent weld PVC piping in 2 parts, primer stage and cementing stage, in accordance with manufacturer's recommendations, ASTM D2855, and CSA requirements.
- .22 Install PVC piping with gasketed joints in accordance with manufacturer's current published specifications, instructions and recommendations, and CSA requirements.

3.2 Installation of Pipe Sleeves

- .1 Where pipes pass through concrete and/or masonry surfaces provide pipe sleeves as follows:
 - .1 in poured concrete slabs – unless otherwise specified, minimum 16 gauge flanged galvanized steel or, where permitted by governing authorities, factory fabricated plastic sleeves;
 - .2 in concrete or masonry walls – Schedule 40 galvanized steel pipe or Class 4000 cast iron pipe.
- .2 Sleeves in waterproofed slabs or walls are to be lengths of Schedule 40 mild galvanized steel pipe with waterstop plate in accordance with drawing detail. Provide waterproof sleeves in following locations:
 - .1 in mechanical room floor slabs, except where on grade;
 - .2 in slabs over mechanical, fan, electrical and telephone equipment rooms or closets;
 - .3 in floors equipped with waterproof membranes;
 - .4 in roof slab;
 - .5 in waterproof walls.
- .3 Size sleeves, unless otherwise specified, to leave 12 mm ($\frac{1}{2}$ ") clearance around pipes, or where pipe is insulated, 12 mm ($\frac{1}{2}$ ") clearance around pipe insulation.

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- .4 Pack and seal void between pipe sleeves and pipe or pipe insulation in non-fire rated construction for length of sleeves as follows:
 - .1 pack sleeves in interior construction with mineral wool and seal both ends of sleeves with non-hardening silicone base caulking compound;
 - .2 pack sleeves in exterior walls above grade with mineral wool and seal both ends of sleeves water-tight with approved non-hardening silicone base caulking compound unless mechanical type seals have been specified;
 - .3 seal sleeves in exterior walls below grade (and any other wall where water leakage may be a problem) with link type mechanical seals as specified.
- .5 Where sleeves are required in masonry work, accurately locate and mark sleeve location, and hand sleeves to mason for installation.
- .6 Terminate piping for sleeves that will be exposed so sleeve is flush at both ends with building surface concerned so sleeve may be completely covered by an escutcheon plate, except for sleeves in waterproof floors which are to terminate 100 mm (4") above finished floor.
- .7 "Gang" type sleeving will not be permitted.
- .8 Where sleeves are provided in non-fire rated construction for future piping, or where piping has been removed from existing sleeves, cap and seal both ends of sleeved opening.

3.3 Installation of Waterproof Mechanical Seals

- .1 Provide watertight link type mechanical seals in exterior wall openings.
- .2 Assemble and install each mechanical seal in accordance with manufacturer's instructions.
- .3 After installation, periodically check each mechanical seal installation for leakage and, if necessary, tighten link seal bolts until seal is completely watertight.

3.4 Duct Openings

- .1 Duct openings, air inlet and outlet openings, fire damper and similar openings will be provided in new poured concrete work, masonry, drywall and other building surfaces by trade responsible for particular construction in which opening is required.
- .2 Size openings for fire dampers to 600 mm (24") high to suit damper arrangement with folding blade out of air stream.
- .3 For duct openings except where fire dampers are required, pack and seal space between duct or duct insulation and duct opening as specified above for pipe openings in non-fire rated construction.

3.5 Sleeve and Formed Opening Location Drawings

- .1 Prepare and submit for review, drawings indicating size and location of required sleeves, recesses and formed openings in poured or precast concrete work.
- .2 Such drawings are to be completely and accurately dimensioned and relate sleeve, recesses, and formed openings to suitable grid lines and elevation datum, and are to take into account structural items such as grade beams, column caps, and column drop slabs.

- .3 Begin to prepare such drawings immediately upon notification of acceptance of bid and award of Contract.

3.6 Installation of Pipe Escutcheon Plates

- .1 Provide escutcheon plates suitably secured over exposed piping passing through finished building surfaces. Finished building surface is any surface with a factory finish or that receives a site applied finish.
- .2 Install plates so they are tight against building surface concerned, completely covering pipe sleeves and/or openings, except where waterproof sleeves extend above floors, in which case fit plate tightly around sleeve.

3.7 Installation of Fastening and Securing Hardware

- .1 Provide fastening and securing hardware required for mechanical work to maintain installations attached to structure or to finished floors, walls and ceilings in a secure and rigid manner capable of withstanding dead loads, live loads, superimposed dead loads, and any vibration of installed products.
- .2 Use fasteners compatible with structural requirements, finishes and types of products to be connected. Do not use materials subject to electrolytic action or corrosion where conditions are liable to cause such action.
- .3 Where floor, wall or ceiling construction is not suitable to support loads, provide additional framing or special fasteners to ensure proper securement to structure that is to support the products. Provide reinforcing or connecting supports where required to distribute loading to structural components.
- .4 Obtain written consent from Owner and review with Consultant, before using explosive actuated fastening devices. If consent is obtained, comply with requirements of CAN/CSA Z166.1 and CAN/CSA Z166.2.

3.8 Installation of Pipe Hangers and Supports

- .1 Provide required pipe hangers and supports.
- .2 Provide any additional structural steel channels, angles, inserts, beam champs and similar accessories required for hanging or supporting pipe. Unless otherwise shown or specified, hang or support pipes from structure only.
- .3 For insulated pipe, size hanger or support to suit diameter of insulated pipe and install hanger or support on outside of insulation and insulation finish.
- .4 Support requirements for underground piping are as follows:
 - .1 support underground service piping penetrating building exterior walls or foundations to prevent pipe damage if minor building settlement occurs, all as per drawing detail;
 - .2 ensure bedding and supports for underground pipes are flat and true and allowances are made for pipe hubs, couplings, or other protrusions so no voids are left between pipe and bedding.
- .5 Unless otherwise shown or specified, hang and/or support horizontal pipe above ground by means of hangers and/or supports specified in Part 2 of this Section. Unless otherwise

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shown or specified, hangers for suspended pipe less than or equal to 25 mm (1") dia. are to be clevis type or adjustable ring type, and hangers for suspended pipe greater than or equal to 40 mm (1-½") dia. are to be adjustable clevis type.

.6 Space hangers and supports in accordance with following:

- .1 cast iron pipe – hang or support at every joint with maximum 2.4 m (8') spacing;
- .2 plastic pipe – conform to pipe manufacturer's recommended support spacing;
- .3 glass pipe – conform to pipe manufacturer's recommended support spacing and support requirements;
- .4 copper and steel pipe – hang or support at spacing in accordance with following schedule:

PIPE DIA.	MAX. SPACING STEEL (meters)	MAX. SPACING COPPER (meters)
to 25 mm (1")	2.4 m (8')	1.8 m (6')
40 mm (1-½")	2.7 m (9')	2.4 m (8')
50 mm (2")	3.0 m (10')	2.7 m (9')
65 mm (2-½")	3.6 m (12')	3.0 m (10')
75 mm (3")	3.6 m (12')	3.0 m (10')
90 mm (3-½")	3.6 m (12')	3.6 m (12')
100 mm (4")	4.2 m (14')	3.6 m (12')
250 mm (10")	6.0 m (20')	
300 mm (12")	6.7 m (22')	

- .5 flexible grooved pipe/coupling joint piping – as above but with not less than one hanger or support between joints.
- .7 Where pipes change direction, either horizontally or vertically, provide a hanger or support on horizontal pipe not more than 300 mm (12") from elbow, and where pipes drop from tee branches, support tees in both directions not more than 50 mm (2") on each side of tee.
- .8 When pipes with same slope are grouped and a common hanger or support is used, space hanger or support to suit spacing requirement of smallest pipe in group and secure pipes in place on common hanger or support.
- .9 Provide roller hangers or supports for heat transfer piping greater than or equal to 150 mm (6") diameter and conveying a material 75°C (170°F) or greater to facilitate pipe movement due to expansion and contraction, and at each hanger or support tack weld a steel protection saddle to pipe to protect piping insulation.
- .10 Unless otherwise shown or specified, support vertical piping by means of supports specified in Part 2 of this Section, spaced in accordance with following:
 - .1 support vertical pipes at maximum 3 m (10') intervals or at every floor, whichever is lesser;

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- .2 for sections of vertical piping with a length less than 3 m (10'), support pipe at least once;
 - .3 for vertical cast iron plain end pipe (mechanical joint type), secure riser or pipe clamp around pipe under a flange integral with pipe for vertical support purposes, or provide a length of hub and spigot pipe to facilitate proper support;
 - .4 for vertical steel pipe risers in excess of 3 m (10'), weld shear lugs to pipe to carry load;
 - .5 for vibration isolated piping risers, provide rubber-steel-rubber vibration isolation pads between riser clamps and floor.
- .11 Support piping on the roof as follows:
- .1 on existing roof – provide support members as specified in Part 2 of this Section spaced as per schedule above and of a type to suit the application, and, for each support, carefully scrape away roofing gravel, bed support in a heavy covering of roofing mastic, then scrape gravel back up around support and secure pipes to supports;
 - .2 on new roof – supply manufactured roof supports as per Part 2 of this Section to accommodate piping involved and support spacing specified above, and hand supports to roofing trade on roof for installation as part of roofing work, then secure piping in place on supports.
- .12 Each hanger, support or securement for horizontal bare copper tubing is to be plastic coated to prevent direct contact between pipe and ferrous hanger. Each wall or floor clamp for vertical bare copper piping is to be isolated from pipe by means of strips of flexible rubber inserts. Use of painted ferrous hangers and supports, including those painted with copper coloured paint, is not acceptable. Site application of tape or other types of isolation is not acceptable.
- .13 For insulated horizontal piping less than or equal to 40 mm (1-½") diameter, provide galvanized steel insulation protection shields between insulation and hanger or support. Install shields immediately after pipe is insulated.
- .14 Do not support piping from steel deck without written consent from Owner and review with Consultant.

3.9 Supply of Access Doors

- .1 Supply access doors to give access to mechanical work which may need maintenance or repair but which is concealed in inaccessible construction, except as otherwise specified herein or on drawings.
- .2 Before commencing installation of mechanical work, coordinate with other trades and prepare on a set of reflected ceiling plans and wall elevations, complete layouts of access doors. Submit these layouts for Consultant's review and show exact sizes and locations of such access doors. Locate and arrange mechanical work to suit.
- .3 Access doors will be installed by trade responsible for particular type of construction in which doors are required. Supply access doors to trade installing same at proper time.
- .4 Wherever possible, access doors to be of a standard size for each application. Review exact dimensions and minimum size restrictions with Consultant prior to ordering.
- .5 Group piping and ductwork to ensure minimum number of access doors is required.

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- .6 Submit a sample of each proposed access door for review with Consultant, prior to ordering.
- .7 Coordinate with Electrical Contractor and General Trades Contractor to ensure access doors on project are provided by a single manufacturer, installed as part of work of General Trades Contractor and work involving both mechanical and electrical services should, where possible, be accessible from common access door. Coordinate work to ensure common location access doors are not supplied by both Mechanical Divisions and Electrical Divisions.
- .8 Identify access doors supplied for concealed medical gas system shut-off valves or equipment with a permanent label in accordance with requirements of CAN/CSA Z7396.1.

3.10 Installation of Valves

- .1 Generally, valve locations are indicated or specified on drawings or specified in Sections of the Specification where valves are specified, however, regardless of locations shown or specified, following requirements apply:
 - .1 provide shut-off valves to isolate systems, at base of vertical risers, in branch take-offs at mains and risers on floors, to isolate equipment, to permit work phasing as required, and wherever else required for proper system operation and maintenance;
 - .2 install shut-off valves with handles upright or horizontal, not inverted, and located for easy access;
 - .3 unless otherwise specified, provide a check valve in discharge piping of each pump;
 - .4 valve sizes are to be same as connecting pipe size;
 - .5 valves are to be permanently identified with size, manufacturer's name, valve model or figure number and pressure rating, and wherever possible, valves are to be product of same manufacturer;
 - .6 for valves in insulated piping, design of valve stem, handle and operating mechanism is to be such that insulation does not have to be cut or altered in any manner to permit valve operation.

3.11 Installation of Pressure Gauges and Thermometers

- .1 Provide pressure gauges in following locations:
 - .1 in valved tubing across suction, suction strainer (if applicable), and discharge piping of each circulating pump;
 - .2 in supply and return piping connections to main mechanical plant equipment such as boilers, chillers, heat exchangers, main coils, etc.;
 - .3 in expansion tank(s);
 - .4 in separate domestic hot water storage tank(s);
 - .5 at top most outlet in each standpipe fire protection system riser;
 - .6 in piping at each side of a pressure reducing valve;
 - .7 in potable water service piping downstream of meter;

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- .8 wherever else shown and/or specified.
- .2 Provide thermometers in following locations:
 - .1 in supply and return piping connections to main mechanical plant equipment such as boilers, chillers, cooling towers, heat exchangers, main coils, etc., unless temperature indication is supplied with equipment;
 - .2 wherever else shown and/or specified.
- .3 Conform to following installation requirements:
 - .1 for installation of thermometers in piping wells, provide a coat of metallic base heat transfer paste or grease in piping well;
 - .2 for pressure gauges in piping at equipment locations, install pressure gauge between equipment and first pipe fitting;
 - .3 locate, mount and adjust instruments so they are easily readable;
 - .4 where pressure gauges and/or thermometers are located at high level or in an area where they cannot be easily seen, provide remote reading instruments.

3.12 Installation of Equipment Drive Guards and Accessories

- .1 Provide OSHA guards for exposed accessible rotating parts such as belt drives, couplings, fan wheels, and shaft ends on mechanical equipment.
- .2 Install belt guards to allow movement of motors for adjusting belt tension.
- .3 Provide a means to permit lubrication and use of test instruments with guards in place.
- .4 Secure guards to equipment or equipment base but do not bridge sound or vibration isolation.
- .5 Where equipment oil level gauges, oil reservoirs, grease cups, or grease gun fittings are integral with equipment but are not easily accessible for service, extend to an accessible location using aluminium or copper tubing.

3.13 Mechanical Work Identification

- .1 Identify new exposed piping and ductwork as per Part 2 of this Section in locations as follows:
 - .1 at every end of every piping or duct run;
 - .2 adjacent to each valve, strainer, damper and similar accessory;
 - .3 at each piece of connecting equipment;
 - .4 on both sides of every pipe and duct passing through a floor, wall or partition, unless otherwise specified;
 - .5 at 6 m (20') intervals on pipe and duct runs exceeding 6 m (20') in length;
 - .6 at least once in each room, and at least once on pipe and duct runs less than 6 m (20') in length.
- .2 Unless otherwise specified identify new concealed piping and ductwork as per Part 2 of this Section in locations as follows:

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- .1 at points where pipes or ducts enter and leave rooms, shafts, pipe chases, furred spaces, and similar areas;
 - .2 at maximum 6 m (20') intervals on piping and ductwork above suspended accessible ceilings, and at least once in each room;
 - .3 at each access door location;
 - .4 at each piece of connected equipment, automatic valve, etc.
- .3 Provide an identification nameplate for equipment provided as part of this project, including items such as control valves, motorized dampers, instruments, and similar products. Secure nameplates in place, approximately at eye level if possible, with stainless steel screws unless such a practice is prohibitive, in which case use epoxy cement applied to cleaned surfaces. Locate nameplates in the most conspicuous and readable location.
- .4 Provide an identification nameplate for each motor starter or disconnect switch located in a motor control centre or on a motor starter panel, and on each individually mounted starter provided as part of mechanical work, and on each disconnect switch provided as part of the electrical work for motorized equipment provided as part of mechanical work.
- .1 if an existing valve tag chart is available at site, valve tag numbering is to be an extension of existing numbering and new valve tag chart is to incorporate existing chart;
 - .2 frame and glaze one copy of chart and, unless otherwise directed, affix to a wall in each main Mechanical and/or Equipment Room;
 - .3 include a copy of valve tag chart in each copy of operating and maintenance instruction manuals;
 - .4 hand an identified CD of valve tag chart to Owner at same time O&M Manuals are submitted.
- .5 Where shut-off valves, control dampers, sensors, and similar items which will or may need maintenance and/or repair are located above accessible suspended ceilings, provide round coloured ceiling tacks in ceiling panel material, or stickers equal to Brady "Quick Dot" on ceiling grid material to indicate locations of items. Unless otherwise specified, ceiling tack or sticker colours are to be as follows:
- .1 HVAC piping valves and equipment: yellow
 - .2 fire protection valves and equipment: red
 - .3 plumbing valves and equipment: green
 - .4 HVAC ductwork dampers and equipment: blue
 - .5 control system hardware and equipment: orange

3.14 Finish Painting of Mechanical Work

- .1 Finish paint exposed mechanical work as specified and/or scheduled in accordance with requirements of Division 09.
- .2 Touch-up paint damaged factory applied finishes on mechanical work products.
- .3 Finish painting of exposed mechanical work is specified in Division 09 and is part of the work of Division 09.

3.15 Pipe Leakage Testing

- .1 Before piping has been insulated or concealed, and before equipment, fixtures and fittings have been connected, test piping for leakage.
- .2 Tests are to be witnessed by Consultant and/or Owner's representative, and, where required, representatives of governing authorities. Give ample notice (minimum 7 working days) of tests in writing and verify attendance. Have completed test report sheets dated and signed by those present to confirm proper test results.
- .3 When circumstances prevent scheduled tests from taking place, give immediate and adequate notice of cancellation to all who were scheduled to attend.
- .4 Gravity Drainage and Vent Piping
 - .1 Test piping in accordance with local governing building code.
 - .2 After fixtures and fittings are set and pipes are connected to building drain or drains, turn on water into pipe, fixtures, fittings and traps in order to detect any imperfect material or workmanship. Perform smoke test if required by local governing authorities.
- .5 Pumped Drainage Piping
 - .1 Test piping with cold water at a pressure of 1-½ times normal working pressure and maintain pressure for minimum of 2 hours.
- .6 Domestic Water Piping
 - .1 Test piping with cold water at a pressure of 1-½ times normal working pressure and maintain pressure for minimum of 2 hours.
- .7 Sprinkler System Piping
 - .1 Test system piping in accordance with requirements of NFPA No. 13, "Installation of Sprinkler Systems", and in accordance with any additional requirements of governing authorities.
- .8 Standpipe System Piping
 - .1 Test system piping in accordance with requirements of NFPA No. 14, "Standpipe and Hose Systems", and in accordance with any additional requirements of governing authorities.
- .9 Clean Agent Fire Extinguishing System Piping
 - .1 Test system piping in accordance with requirements of NFPA No. 2001, "Standard on Clean Agent Extinguishing Systems", and in accordance with any additional requirements of governing authorities.
- .10 Heat Transfer (HVAC) System Piping
 - .1 Test piping with cold water at pressure of 1035 kPa (150 psi) for minimum of 2 hours.
- .11 Steam and Condensate Piping
 - .1 Test piping with cold water for minimum of 2 hours at following pressures:
 - .1 0 kPa to 105 kPa (0 psi to 15 psi) low pressure piping – 690 kPa (100 psi);

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- .2 110 kPa to 690 kPa (16 psi to 100 psi) medium pressure piping – 1035 kPa (150 psi);
- .3 greater than 690 kPa (100 psi) high pressure piping – 1380 kPa (200 psi).

.12 Natural Gas Piping

- .1 Test piping in accordance with requirements of CAN/CSA B149.1 and any additional requirements of local governing authorities.
- .2 After completion of the verification test, locate required tag stating results of verification test at point of entry of gas main into building, affixed to pipe in secure manner.
- .3 Check piping joints and connections for leaks with water/soap solution while piping is under pressure.

.13 Propane Gas Piping

- .1 Test piping in accordance with requirements of CAN/CSA B149.2 and any additional requirements of local governing authorities.
- .2 After completion of verification test, locate required tag stating results of verification test at point of entry of gas main into building, affixed to pipe in secure manner.
- .3 Check piping joints and connections for leaks with water/soap solution while piping is under pressure.

.14 Compressed Air Piping

- .1 Test piping with dry compressed air or nitrogen at 690 kPa (100 psi) for minimum of 2 hours.
- .2 Test piping joints with water-soap solution while piping is under pressure to detect leaks.

.15 Fuel Oil Piping

- .1 Test piping (not tanks) with dry compressed air or nitrogen for minimum period of 2 hours at 1035 kPa (150 psi).
- .2 Check piping joints and connections for leaks with water/soap solution while piping is under pressure.

.16 Gasoline Piping

- .1 Test piping (not tanks) with dry compressed air or nitrogen for minimum period of 2 hours at 1035 kPa (150 psi) in accordance with TSSA requirements.
- .2 Check piping joints and connections for leaks with water/soap solution while piping is under pressure.

.17 Refrigerant Piping

- .1 Test refrigerant piping for leakage and dehydrate in accordance with requirements of ASHRAE Handbook - Refrigeration, Chapter 8 - Equipment and System Dehydrating, Charging, and Testing.

.18 Control Air Piping and Tubing

- .1 Test control air piping and tubing with dry compressed air or nitrogen before concealing and again before connection of instruments.

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- .2 Rough-in test pressure is to be 345 kPa (50 psi) maintained over 24 hours with pressure drop not to exceed 35 kPa (5 psi).
- .3 Test joints for leaks with soap solution.
- .4 Finish test is to be 205 kPa (30 psi) with permissible loss of 7 kPa (1 psi) over 4 hour period. Prior to connecting instruments, blow systems clean and dry, and test component connections for leaks with water/soap solution.
- .19 Medical Gas System Piping
 - .1 Perform leakage and flow tests for piping using oil-free compressed air or oil-free dry nitrogen in accordance with requirements of CAN/CSA Z7396.1.
- .20 Pure Water Piping
 - .1 When piping has been properly flushed and cleaned, test at 690 kPa (100 psi) for 2 hours with only distilled water or filtered dry compressed air. If distilled water is used, drain system when testing is complete.
- .21 Following requirements apply to all testing:
 - .1 ensure piping has been properly flushed, cleaned and is clear of foreign matter prior to pressure testing;
 - .2 temporarily remove or valve off piping system specialties or equipment which may be damaged by test pressures prior to pressure testing systems, and flush piping to remove foreign matter;
 - .3 when testing is carried out below highest level of particular system, increase test pressure by the hydrostatic head of 7 kPa (1 psi) for every 600 mm (24") below high point;
 - .4 include for temporary piping connections required to properly complete tests;
 - .5 piping under test pressure is to have zero pressure drop for length of test period;
 - .6 make tight leaks found during tests while piping is under pressure, and if this is impossible, remove and refit piping and reapply test until satisfactory results are obtained;
 - .7 where leaks occur in threaded joints in steel piping, no caulking of these joints will be allowed under any conditions;
 - .8 perform tests in reasonably sized sections so as to minimize number of tests required;
 - .9 in addition to leakage tests specified above, demonstrate proper flow throughout systems including mains, connections and equipment, as well as proper venting and drainage, and include for any necessary system adjustments to achieve proper conditions.

3.16 Supply of Motor Starters and Accessories

- .1 Motor starters for mechanical equipment, except for starters integral with packaged equipment and starters factory installed in equipment power and control panels, will be provided as part of electrical work.
- .2 Unless otherwise shown or specified, supply starter for each item of motorized equipment. Refer to Motor Starter Schedule.

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- .3 Where package type equipment with integral starters, or equipment with starters integral in loose power and control panels supplied with equipment is fed from motor control centre, provide disconnect switch in motor control centre in lieu of motor starter.
- .4 Where 3-phase starters are indicated and/or scheduled to be mounted on a motor starter panel, starters will be mounted and connected, complete with panels and splitter trough, as part of electrical work. Hand starters to electrical trade at site when they are required.
- .5 Where package type equipment with integral starters, or equipment with starters integral in loose power and control panels supplied with equipment is fed from motor starter panel, disconnect switch will be provided on motor starter panel as part of electrical work.
- .6 Unless otherwise specified or shown on drawings, 1-phase motor starters will be mounted adjacent to equipment they serve and connected complete as part of electrical work. Hand starters to electrical trade at site at proper time.

3.17 Electrical Wiring Work for Mechanical Work

- .1 Coordinate requirements and responsibilities for electrical wiring with Electrical Division 26 Contractor. Provide low voltage control wiring not provided under work of Division 26.
- .2 Unless otherwise specified or indicated, following electrical wiring work for mechanical equipment will be done as part of electrical work:
 - .1 "line" side power wiring to motor starters or disconnect switches in motor control centres and starters or disconnects on motor starter panels, and "load" side wiring from starters or disconnects to equipment;
 - .2 "line" side power wiring to individual wall mounted starters, and "load" side wiring from starters to equipment;
 - .3 "line" side power wiring to pre-wired power and control panels and variable frequency drives (VFD), and "load" side power wiring from the panels and VFD's to equipment;
 - .4 provision of receptacles for plug-in equipment;
 - .5 provision of disconnect switches for motors in excess of 9 m (30') from starter location, or cannot be seen from starter location, and associated power wiring;
 - .6 motor starter interlocking in excess of 24 volts;
 - .7 wiring from motor winding thermistors in motors 30 HP and larger to motor starter contacts;
 - .8 120 volt power connections to electrical receptacles integral with small ceiling exhaust fans, including wiring through light switches or speed controllers;
 - .9 120 volt wiring connections to lighting fixture/switch combinations integral with air handling units;
 - .10 120 volt wiring connections to duplex receptacles integral with air handling unit control panels.
- .3 Mechanical wiring work not listed above or specified herein or on drawings to be done as part of electrical work is to be installed in conduit and is to be done as part of mechanical work in accordance with wiring requirements specified for electrical work.

3.18 Interruption to and Shut-Down of Mechanical Services and Systems

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- .1 Coordinate shut-down and interruption to existing mechanical systems with Owner. Generally, shut-downs may be performed only between the hours of 12:00 midnight Friday until 6:00 a.m. Monday morning. Include for costs of premium time to perform work during nights, weekends or other times outside of normal working hours, which may be necessary to comply with stipulations specified herein this Article. Services for operation of existing non-renovated areas of building are to be maintained.
- .2 Upon award of a Contract, submit a list of anticipated shut-down times and their maximum duration.
- .3 Prior to each shut-down or interruption, inform Owner and Consultant in writing minimum 7 working days in advance of proposed shut-down or interruption and obtain written consent to proceed. Do not shut-down or interrupt any system or service without such written consent. Shutdowns of some essential services may require additional advance notification time.
- .4 Perform work associated with shut-downs and interruptions as continuous operations to minimize shut-down time and to reinstate systems as soon as possible, and, prior to any shut-down, ensure materials and labour required to complete the work for which shut-down is required are available at site.
- .5 Pipe freezing may be used to connect new piping to existing piping without draining existing piping. Pipe freeze equipment is to be equal to "NORDIC FREEZE" equipment supplied by Mag Tool Inc. (1-800-661-9983) or Rigid Tool Co. RIGID "SuperFreeze".
- .6 Confirm any methods of procedures with Owner and review with Consultant prior to start of work.

3.19 Equipment Bases and Supports

- .1 Unless otherwise specified or indicated on drawings, set floor mounted equipment on minimum 100 mm (4") high reinforced concrete housekeeping pads 200 mm (8") clear of equipment on each side and end, or a minimum of 200 mm (8") from centreline of equipment anchor bolts to edge of the base, whichever is larger. Conform to following requirements:
 - .1 supply dimensioned drawings and equipment base templates, and provide anchor bolts for proper setting and securing of equipment on pads;
 - .2 place anchor bolts during concrete pour and be responsible for required levelling, alignment, and grouting of equipment;
 - .3 as a minimum, use wire mesh reinforcement, however, for pads for large heavy equipment, use reinforcement as per structural drawing details.
- .2 For equipment not designed for base mounting, where required, provide welded, cleaned and prime coat painted structural steel stands or supports conforming to following requirements:
 - .1 provide stands and supports, except those for small equipment, designed by a structural engineer registered in jurisdiction of the work, and submit stamped and signed design drawings with calculations as shop drawings for review;
 - .2 flange bolt steel stands to concrete housekeeping pads;
 - .3 seismically restrained stands and supports in accordance with applicable requirements.

3.20 Mechanical Service Requirements for Floating Floor Slabs

- .1 Where mechanical services are required to be installed in or through a vibration isolated floating slab, install such services so as not to transmit any vibration to base slab on which floating floor slab is placed.
- .2 Wherever possible, arrange mechanical work to avoid penetrating a floating floor slab.

3.21 Concrete Work for Mechanical Equipment Bases/Pads

- .1 Concrete work required for mechanical equipment bases/pads will be provided as part of concrete work of Division 03.
- .2 Exactly locate bases/pads at site and be present during concrete pour to ensure anchor bolts, inserts, plates and similar hardware are not damaged or dislodged.
- .3 Coordinate base/pad installations with concrete trade and ensure bases and pads are keyed into structure to meet seismic restraint requirements.

3.22 Concrete Work for Mechanical Equipment Bases/Pads

- .1 Provide poured concrete work, including reinforcing and formwork, required for mechanical equipment bases/pads. Perform concrete work in accordance with requirements specified in Division 03. Coordinate work with Division 03.
- .2 Submit for review, dimensioned shop drawings, prepared and stamped by a professional structural engineer registered in the jurisdiction of the work, for concrete pads or bases for support of large, heavy equipment. Indicate on shop drawings total weight of pad or base as well as equipment it is provided for, and concrete reinforcing.
- .3 Excavation, backfill and related work such as dewatering required for mechanical work will be performed as part of excavation and backfill work of Division 31, except for final hand grading work which is to be done as part of mechanical work. Mark out location and routing of excavation required for work as well as required depth. Ensure that bedding is graded to provide proper drainage for ducts as reviewed with Consultant.
- .4 Inverts and locations of existing site services may have been site surveyed and approximate location may be shown on drawings. Confirm local utilities have performed locates and marking out. Ensure inverts and locations are correct, prior to commencement of work. Where discrepancies are found, immediately inform Consultant, and await a direction.
- .5 Accurately mark-out location and routing of excavation required, as well as required depth.
- .6 Ensure that bases and pads are keyed into the structure to meet seismic restraint requirements.

3.23 Cutting, Patching and Core Drilling

- .1 Cutting and patching of existing building surfaces required for mechanical work, including core drilling walls and slabs for piping, will be done as part of another Division of the work and is excluded from mechanical work.
- .2 Accurately and carefully mark out location and extent of cutting or drilling required and coordinate with trade(s) performing the work. Location and size of cut or drilled openings must be approved by Consultant before work commences, and cut or drilled openings

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must not be larger than is absolutely necessary for installation of pipe, duct, etc., and insulation where necessary.

- .3 Ensure openings in fire rated construction are firestopped and sealed in accordance with requirements of article entitled Firestopping and Smoke Seal Materials in this Section. Ensure openings are not left open overnight unless approved by Owner and reviewed with Consultant.

USE FOLLOWING ARTICLE IF CUTTING AND PATCHING OF EXISTING BUILDING IS PART OF MECHANICAL WORK.

3.24 Packing and Sealing Core Drilled Pipe Openings

- .1 Pack and seal void between pipe opening and pipe or pipe insulation for length of opening as follows:
 - .1 non-fire rated interior construction – pack with mineral wool and seal both ends of opening with non-hardening silicone base caulking compound to produce a water-tight seal;
 - .2 exterior walls above grade – pack with mineral wool and seal both ends of sleeves water-tight with non-hardening silicone base caulking compound unless mechanical type seals have been specified;
 - .3 exterior walls below grade (and any other wall where water leakage may be a problem) – seal with link type mechanical seals as specified.

3.25 Flashing for Mechanical Work Penetrating Roof

- .1 Perform required flashing work, including counter-flashing, for mechanical work penetrating and/or set in roof.
- .2 Perform flashing work in accordance with requirements of drawing details, and requirements specified in Division 07.

3.26 Cleaning Mechanical Work

- .1 Refer to cleaning requirements specified in Division 01.
- .2 Clean mechanical work prior to application for Substantial Performance of the Work.
- .3 Include for vacuum cleaning interior of air handling units and ductwork systems.

3.27 Connections to Other Equipment

- .1 Carefully examine Contract Documents during bidding period and include for mechanical work piping and/or ductwork connections to equipment requiring such connections.

3.28 Installation of Flexible Connectors

- .1 Provide flexible connectors in piping connections to seismically restrained equipment, and wherever else shown.
- .2 Provide flexible connectors in piping connections to vibration isolated equipment.

3.29 Fan Noise Levels

- .1 Submit sound power levels with fan shop drawings/product data, with levels measured to AMCA 300 and calculated to AMCA 301.

3.30 Equipment and System Manufacturer's Certification

- .1 When equipment/system installation is complete, but prior to start-up procedures, arrange and pay for equipment/system manufacturer's authorized representative to visit site to examine installation, and after any required corrective measures have been made, to certify in writing to Owner and Consultant that equipment/system installation is complete and in accordance with equipment/system manufacturer's instructions.

3.31 Equipment and System Start-Up

- .1 When installation of equipment/systems is complete but prior to commissioning, perform start-up for equipment/systems as specified in mechanical work Sections and in accordance with following requirements:
 - .1 submit a copy of each equipment/system manufacturer's start-up report sheet to Consultant for review, and incorporate any comments made by Consultant, Owner or Commissioning Agent, as applicable;
 - .2 under direct on-site supervision and involvement of equipment/system manufacturer's representative, start-up equipment/systems, make any required adjustments, document procedures, leave equipment/systems in proper operating condition, and submit to Consultant complete set of start-up documentation sheets signed by manufacturer/supplier and Contractor;
 - .3 submit documents signed by equipment/system manufacturer testing technician, in both hard copy and pdf electronic copy formats.

3.32 Integrated Systems Testing

- .1 Perform testing of integrated systems and equipment in accordance with CAN/ULC-S1001.
- .2 Engage respective systems or equipment vendors or trades to be onsite during inspection and testing work to perform adjustments or remedial work to correct issues identified by inspection and testing work.

3.33 Seismic Restraint Anchor Points For Equipment

- .1 Mechanical equipment requiring seismic restraint (refer to Section entitled Seismic Control and Restraint) is to be complete with manufacturer designed and rated seismic restraint anchor points and attachments, certified by equipment manufacturers, so equipment may be bolted down or restrained in the field.
- .2 Design equipment to be restrained such that strength and anchorage of internal components of equipment exceeds force level used to restrain and anchor equipment itself to supporting structur

END OF SECTION

Seismic Control and Restraint

1 GENERAL

1.01 APPLICATION

- .1 This Section specifies seismic control and restraint requirements that are common to mechanical work Sections of the Specification and it is a supplement to each Section and is to be read accordingly.

1.02 SEISMIC CONSULTANT

- .1 Provide services of an experienced Seismic Consultant who is a registered professional engineer licensed in the jurisdiction of the work and a member in good standing of a Professional Engineers Association in the jurisdiction of the work.
- .2 Seismic Consultant is to:
 - .1 determine proper seismic hazard level, design, recommend, and review proposed mechanical work seismic restraint shop, placement and securing drawings, and sign and stamp drawings prior to submittal for review as specified below;
 - .2 supervise installation of mechanical work seismic restraint and, when work is complete, certify in writing that seismic restraint work has been installed in accordance with signed, stamped and reviewed drawings;
 - .3 prepare and submit to Municipality and authorities having jurisdiction, on a form approved by Municipality and authorities having jurisdiction, at the beginning of seismic restraint work and when work is complete, original signed and sealed Letters of Assurance for design, installation and field review of seismic restraint work.

1.03 SUBMITTALS

- .1 Obtain required equipment information and submit manufacturer's shop drawings/product data sheets for restraining devices and steel bases. Include placement data, and details of attachment to both equipment and structure meeting requirements of forces involved. Product data sheets and drawings are to be signed and stamped by Seismic Consultant referred to above.
- .2 Submit copies of Seismic Consultant's Letters of Assurance as specified above.
- .3 Submit copies of Seismic Consultant and seismic control manufacturer's certification letters as specified in Part 3 of this Section.
- .4 If requested, submit samples of seismic restraint materials for review.
- .5 Submit minimum one hard copy and electronic pdf version of documents.

Seismic Control and Restraint

1.04 QUALITY ASSURANCE

- .1 Seismic restraints are to be designed by a registered professional engineer as specified above, and are to be installed by qualified tradesmen under supervision of and to the approval of the design engineer.
- .2 Unless otherwise specified, seismic control and restraints are to be designed in accordance with local governing code requirements, ANSI/SMACNA Seismic Restraint Manual: Guidelines for Mechanical Systems, SMACNA/ASHRAE Service Restraint Applications CD-ROM, and P.P.I.C. Manual Guidelines for Seismic Restraints of Mechanical Systems and Plumbing Piping Systems, all of which are to form a part of this Section.
- .3 Seismic control and restraints for fire protection piping and equipment are to be in accordance with NFPA requirements. When specified and/or required, design is also to include Factory Mutual requirements.
- .4 Restraint products must be tested in independent testing laboratory, or certified by Seismic Consultant, to confirm restraint products meet requirements of this Section, i.e. dynamic ultimate limit load state as required by local governing code, "Fail Safe" design, etc. If tests are carried out to represent a restraint type, test is to be valid for full load range of restraint. Submit such tests or certification when requested.
- .5 Seismic control and restraint product manufacturers are to provide required assistance during installation, and, when installation is complete, submit written reports listing any deficiencies to installation.

2 PRODUCTS

2.01 GENERAL

- .1 Isolation, anchors, bolts, bases, restraints, etc., are to be designed to withstand without failure or yielding, dynamic G load as specified in local governing code for seismic zone in which building is located. Design loads are ultimate limit state loads (1.5 times working load) acting through the centre of gravity of the anchored or restrained equipment. "Fail Safe" designs are acceptable.
- .2 For both isolated and non-isolated floor mounted equipment, i.e. tanks, heat exchangers, boilers, etc., design and provide anchors and bolts to withstand, without failure or yielding, a dynamic ultimate limit state load as defined in local governing code, of the greater of 0.3 g or as required by local governing codes and standards, applied horizontally through centre of gravity.
- .3 Where impact forces may be significant, use ductile materials.
- .4 Seismic restraining devices factory supplied with equipment are to meet requirements of this Section.
- .5 Acceptable manufacturers are:
 - .1 Mason Industries Inc.;
 - .2 Kinetics Noise Control;
 - .3 Vibro-Acoustics Ltd;

Seismic Control and Restraint

.4 Price Industries Inc.

2.02 SLACK CABLE RESTRAINTS

- .1 Aircraft cable galvanized slack cable restraints meeting current requirements of local governing building code, sized to suit the application and complete with required cable ties, anchor hardware (selected for a load equal to twice the weight of the equipment), and similar connection accessories.

2.03 ANCHOR BOLTS

- .1 Equal to Mason Industries type SAB seismic anchor bolts.

2.04 FLEXIBLE PIPING CONNECTIONS

- .1 Flexible piping connectors are to be supplied with seismic restraint materials. Where flexible connections are not specified with piping in other Sections they are to be equal to Mason Industries twin sphere, non-metallic connectors with hose lengths preset in strict accordance with manufacturer's instructions and to approval of Seismic Consultant, each rated for continuous operation at 1725 kPa at 87.7°C (250 psi at 190°F) or 1380 kPa at 121°C (200 psi at 250°F), and complete with:
 - .1 nylon tire cord reinforced EPDM body;
 - .2 ductile iron reinforcing ring and ductile iron screwed or flanged connections as required and to suit piping system operating pressure.

2.05 VIBRATION ISOLATION PRODUCTS

- .1 Refer to Section entitled Mechanical Vibration Control.

3 EXECUTION

3.01 INSTALLATION OF SEISMIC RESTRAINT MATERIALS

- .1 Provide seismic restraint for mechanical equipment, piping, and ductwork, including diffusers, grilles, etc., as per requirements of current edition of local governing building code and this Section of the Specification.
- .2 Following Mechanical Components Restraint Guide is to be used as a general guide only to establish appropriate restraint methods, hardware, and attachments, however, due to differences in construction, size, weight, and configuration of different manufacturer's equipment and variety of ways and means that equipment and components can be installed, specific restraint methods are to be confirmed in the field. Seismic restraint materials and methods are to be reviewed and approved by Seismic Consultant.

Seismic Control and Restraint

MECHANICAL COMPONENT RESTRAINT GUIDE

ITEM	TYPE OF RESTRAINT	MIN. NO. OF RESTRAINTS	NOTES
In-line Pumps	SCR	2	Pipe mounted type pump
Pumps Non-Isolated	BTHP	4	Base mount type pump
Pumps Isolated	SNBR	4	Base mount type pump
Expansion Tanks	SCR	4	
D.H.W. Tanks	SCR	4	Attach to removable steel strap yoke
Glycol Tanks	SCR	4	Attach to removable steel strap yoke
Boilers			
- With Base	BTHP	4	
- Without Base	CSSB	4	
Chillers			
- Isolated	SNBR	4	
- Non-Isolated	BTHP	4	
Cooling Towers Closed Circuit Coolers			
- Isolated	SNBR	4	
- Non-Isolated	BTSLPR	4	
Heat Exchangers	BTHP	4	Bolt to custom support frame
Radiant Panels	SCR	4	Per panel section
Unit Heaters	TSR-SCR	4	
Force Flow Heaters	TSR-SCR	4	
AHU's and A/C Units Free Standing			
- With Base	BTHP	4	
- Without base	CSSB	4	
AHU's and A/C Units Suspended			
- Isolated	SCR	4	
- Non-Isolated	SCR	4	
Packaged Rooftop Air Units (all types)			

Seismic Control and Restraint

ITEM	TYPE OF RESTRAINT	MIN. NO. OF RESTRAINTS	NOTES
On roof curb	BTRC	4	Roof curb bolted to roof.
Humidifiers	BTHP	4	Bolt unit to custom stand.
Electronic		4	Bolt stand to housekeeping pad or structure.
Fans – Suspended			
- Isolated	SCR	4	
- Non-Isolated	SCR	4	
Fans – Freestanding			
- Isolated	SNBR	4	
- Non-Isolated	BTHP	4	
Grilles, Registers, Diffusers	SCR	4	Where not bolted to duct (i.e. in tee-bar ceilings)
Airflow Control Valves	SCR	4	Where suspended
Air Compressor Receiver Sets			
- Isolated	BTHP	4	
- Non-Isolated			
Piping	SCR TSR	As required	As per Specification
Ductwork	SCR TSR	As required	As per Specification

LEGEND	
SCR	Slack cable restraint (bolted to structure)
SNBR	Seismic snubber (bolted to structure)
TSR	Threaded support rod (bolted or clamped to structure)
BTSLPR	Bolt to sleeper (sleeper bolted to structure)
BTHP	Bolt to concrete housekeeping pad (pad to be keyed to structure)
CSSB	Custom steel shoe base (bolted to structure)
BTRC	Bolt to roof curb (roof curb bolted to roof structure)

- .3 Provide structural steel bases for equipment unless equipment manufacturer certifies direct attachment capabilities.

Seismic Control and Restraint

- .4 Space restraints under equipment so minimum distance between adjacent corner restraints is at least equal to the height of the centre of gravity of equipment. Include height of centre of gravity on shop drawings, otherwise, design for increased forces on supports and submit design calculations with shop drawings. Chillers are to meet this requirement.
- .5 Install floor mounted isolated equipment on 100 mm (4") high concrete housekeeping pads with at least 200 mm (8") clearance between drilled inserts and edges of pads. Ensure housekeeping pads are keyed to structure to resist seismic displacement.
- .6 Requirements pertaining to seismic control work are as follows:
 - .1 execute seismic control and restraint work in accordance with drawing details, reviewed shop drawings, ANSI/SMACNA Seismic Restraint Manual, PIPC Manual: Guidelines for Seismic Restraints of Mechanical Systems and Plumbing Piping Systems, and National Uniform Seismic Installation Guidelines (NUSIG);
 - .2 seismic control systems are to work in all directions;
 - .3 fasteners and attachment points are to resist same maximum load as the seismic restraint;
 - .4 drilled or power driven anchors and fasteners are not permitted;
 - .5 no equipment, equipment supports or mounts are to fail before failure of structure;
 - .6 supports of cast iron or threaded pipe are not permitted;
 - .7 seismic control measures are not to interfere with integrity of firestopping;
 - .8 equipment is to be bolted to structure, and bolts are to be fitted with isolation washers;
 - .9 number, size, type, and installation of anchor bolts are to be as recommended by anchor bolt manufacturer and seismic design consultant;
 - .10 where more than a 3 mm (1/8") differential exists between an anchor or attachment bolt diameter, an anchor and attachment point hole, or an isolator gap attachment bolt and equipment anchor attachment hole, pack air gap with Mason type 0.5 FastSteel reinforced epoxy putty;
 - .11 hung equipment and pipe hangers are to be fitted with a means of preventing upward movement, and non-isolated equipment and pipe hanger rods are to be fitted with oversized steel washers and nuts above and below hanger or equipment attachment point, locked tight to prevent uplift of equipment or hanger;
 - .12 where suspended equipment hanger rod length exceeds 50 rod diameters between structure and equipment attachment point, reinforce rods with angle iron to prevent bending due to uplift forces;
 - .13 seismic control measures are not to jeopardize noise and vibration isolation systems, and 6 mm (1/4") to 9 mm (3/8") clearance during normal operation of equipment and systems is to be provided between seismic restraint and equipment;

Seismic Control and Restraint

- .14 where hold-down bolts for seismic restraint equipment penetrate roofing membranes coordinate with roofing trade for installation of pitch pockets/"gum cups" and sealing compound to maintain water-tight integrity of roof;
- .15 where friction type clamps are used for support of equipment and connecting services, secure clamps to steel work by means of welding or other positive means to prevent slippage or loosening of clamps due to seismic forces.
- .7 Provide slack cable restraint assemblies for:
 - .1 steam piping 32 mm (1-1/4") dia. and larger;
 - .2 fuel gas, fuel oil, medical gas, compressed air and service piping 25 mm (1") dia. and larger;
 - .3 piping 32 mm (1-1/4") dia. and larger located in boiler, fan, chiller, and similar equipment rooms;
 - .4 horizontal and vertical piping 65 mm (2-1/2") dia. and larger;
 - .5 ductwork and duct mounted equipment;
 - .6 isolated and non-isolated ceiling hung fans, tanks, equipment, etc.;
 - .7 generator exhaust system(s).
- .8 Installation requirements for slack cable restraints include following:
 - .1 connect slack cable restraints to ceiling hung equipment in such a way that axial projection of wires passes through centre of gravity of the equipment;
 - .2 orient restraint wires on ceiling hung equipment at approximately 90° to each other (in plan), and tie back to ceiling slab at an angle not exceeding 45° to slab;
 - .3 install cables using appropriate grommets, shackles, and other hardware to ensure alignment of restraints and to avoid bending cables at connection points, and, where feasible, wrap cables directly around pipes as opposed to using collars;
 - .4 for piping systems, provide transverse slack cable restraints at a maximum spacing of 12.5 m (40'), and longitudinal restraints at 25 m (80') maximum spacing, or as limited by anchor/slack cable performance;
 - .5 for piping less than 250 mm (10") dia., reduce transverse restraint spacing to 6 m (20'), and note that smaller piping may be rigidly tied to larger piping for restraint, but not reverse;
 - .6 vary adjacent spacing of restraints on a piping run by 10% to 30% to avoid coincident resonance;
 - .7 transverse bracing for one pipe section may also act as longitudinal bracing for piping connected perpendicular to it if bracing is installed within 600 mm (24") of elbow or tee, and if connected piping is same or smaller dia., and note that branch lines are not to be used to restrain main lines;

Seismic Control and Restraint

- .8 provide flexibility in piping joints or sleeves where piping penetrates building seismic or expansion joints;
- .9 wherever possible, support weight of vertical piping risers at a point or points above the centre of gravity of riser, and provide lateral guides at top and bottom of riser, and at intermediate points not to exceed the transverse spacing specified above for horizontal pipes, with guide clearance not exceeding 3 m (10');
- .10 install restraints at least 50 mm (2") clear of other equipment and services;
- .11 adjust restraint cables such that they are not visibly slack, or such that flexibility is approximately 40 mm (1-½") under thumb pressure for a 1.5 m (5') cable length, with an equivalent ratio for other cable lengths, and adjust clearance of cable strap/spacer piece restraints so as not to exceed 6 mm (0.23");
- .12 provide transverse and axial restraints within 4 m (12') of a vertical bend;
- .13 at steel trusses, connect to top chords at panel points and follow truss manufacturer's instructions;
- .14 diffusers and grilles mounted in T-bar ceilings or which are not positively secured to ductwork or structure are to be fitted with slack cable restraints to prevent them from falling in the event the ceiling T-bar grid is displaced;
- .15 do not bridge vibration isolators with slack cable restraints;
- .16 other approved restraint systems are conventional pipe guides, rigid restraint where piping passes through a block or concrete wall, or a cable strap and spacer piece attached to structure and used where piping is adjacent to a wall and conventional slack cable restraints cannot be used.

3.02 INSTALLATION OF FLEXIBLE PIPING CONNECTORS

- .1 Supply flexible piping connectors for connections (including plumbing) to seismically restrained equipment. Hand connectors to appropriate piping trade at site for installation.

3.03 SITE INSPECTION AND LETTERS OF CERTIFICATION

- .1 When seismic control products have been installed, arrange for seismic control product manufacturer and Seismic Consultant to examine installation of seismic control products and to certify in writing (separate letters) that products have been properly installed in accordance with local governing codes and regulations, and recommendations and instructions. Seismic Consultant is to apply his professional stamp to letter.

END OF SECTION

PART 1 - GENERAL

1.1 Application

- .1 This Section specifies insulation requirements common to Mechanical Divisions work Sections and it is a supplement to each Section and is to be read accordingly.

1.2 Definitions

- .1 "concealed" – means mechanical services and equipment above suspended ceilings, in non-accessible chases, in accessible pipe spaces, and furred-in spaces.
- .2 "exposed" – means exposed to normal view during normal conditions and operations.
- .3 "mineral fibre" – includes glass fibre.
- .4 "mineral wool" – includes rock wool and slag wool.
- .5 "domestic water" or "potable water" – means piping extended from building Municipal supply main.

1.3 Submittals

- .1 For fire rated duct wrap, submit ULC FRD design documentation as part of shop drawing.
- .2 In accordance with Part 3 of this Section, submit a letter from fire rated duct wrap supplier certifying duct wrap has been properly installed.
- .3 Submit a colour chart for coloured lagging adhesive for canvas jacketed insulation.

1.4 Quality Assurance

- .1 Mechanical insulation is to be applied by a licensed journeyman insulation mechanic, or by an apprentice under direct, daily, on-site supervision of a journeyman mechanic.
- .2 Do not apply insulation unless leakage tests have been satisfactorily completed.
- .3 Ensure surfaces to be insulated are clean and dry.
- .4 Ensure ambient temperature is minimum 13°C (55°F) for at least 1 day prior to application of insulation, and for duration of insulation work, and relative humidity is and will be at a level such that mildew will not form on insulation materials.

PART 2 - PRODUCTS

2.1 Fire Hazard Ratings

- .1 Unless otherwise specified, insulation system materials inside building must have a fire hazard rating of not more than 25 for flame spread and 50 for smoke developed when tested in accordance with ULC S102, Surface Burning Characteristics of Building Materials and Assemblies.

2.2 Thermal Performance

- .1 Unless otherwise specified, thermal performance of insulation is to meet or exceed values given in Tables entitled Minimum Piping Insulation Thickness Heating and Hot Water Systems and Minimum Piping Insulation Thickness Cooling Systems, as stated in ANSI/ASHRAE/IES Standard 90.1 version referenced in Ontario Building Code.

Mechanical Insulation

2.3 Pipe Insulation Materials

- .1 Horizontal Pipe Insulation at Hangers and Supports
 - .1 Equal to Belform Insulation Ltd. "Koolphen K-Block" insulated pipe support inserts consisting of minimum 150 mm (6") long, pre-moulded, rigid, sectional phenolic foam insulation (of same thickness as adjoining insulation) with a reinforced foil and kraft paper vapour barrier jacket and a captive galvanized steel saddle.
- .2 Flexible Foam Elastomeric
 - .1 Closed cell, sleeve type, longitudinally split self-seal, foamed plastic pipe insulation with a water vapour transmission rating of 0.10 in accordance with ASTM E96, Procedure B, and required installation accessories.
 - .2 Acceptable products are:
 - .1 Armacell AP/Armaflex;
 - .2 IK Insulation Group K-Flex "LS" Self-Seal Pipe Insulation.
- .3 Closed Cell Foamed Glass
 - .1 Pittsburgh Corning "FOAMGLAS", expanded, sectional, rigid sleeve type insulation with a liquid or vapour permeability rating (in accordance with ASTM C240) of 0.00, and a factory applied "PITTWRAP SSII" self-sealing jacket.
- .4 Pre-Moulded Mineral Wool
 - .1 Rigid, sectional, sleeve type, fire-rated, non-combustible, longitudinally split mineral wool or basalt pipe insulation with a reinforced vapour barrier jacket, and compatible with ULC S115 and ULC S101 firestopping.
 - .2 Acceptable products are:
 - .1 Roxul "Tecton 1200";
 - .2 IIG (Johns Manville Inc.) MinWool-1200.
- .5 Pre-Moulded Calcium Silicate
 - .1 Non-combustible, high-temperature insulation to ASTM C553 with maximum flame spread/smoke developed rating of 25/50 in accordance with ULC S102.
 - .2 Acceptable products are:
 - .1 Johns Manville Inc. "Thermo-12 Gold";
 - .2 Industrial Insulation Group "Thermo-12 Gold".

2.4 Barrier-Free Lavatory Piping Insulation Kits

- .1 Removable, flexible, reusable, white moulded plastic insulation kits for barrier-free lavatory drain piping and potable water supplies exposed under lavatory.
- .2 Acceptable products are:
 - .1 Truebo "Lav-Guard 2" E-Z Series;
 - .2 Zeston "SNAP-TRAP";
 - .3 McGuire Manufacturing Co. Inc. "ProWrap".

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2.5 Equipment Insulation Materials

- .1 Blanket Mineral Fibre
 - .1 Blanket type roll form insulation to ASTM C553, 24 kg/m³ (1-½ lb/ft³) density, with a factory applied vapour barrier facing.
 - .2 Acceptable products are:
 - .1 Johns Manville Inc. Microlite FSK Duct Wrap Type 150;
 - .2 Knauf Fiber Glass Blanket Insulation FSK Duct Wrap Type III;
 - .3 Manson Insulation Inc. ALLEY WRAP FSK Duct Wrap Type III;
 - .4 Certainteed Corporation Softtouch FSK Duct Wrap Type 150.
- .2 Semi-Rigid Mineral Fibre Board
 - .1 Roll form, moulded insulation to ASTM C1393, with a factory applied vapour barrier facing consisting of laminated aluminium foil and kraft paper.
 - .2 Acceptable products are:
 - .1 Knauf Fiber Glass Pipe and Tank Insulation;
 - .2 Manson Insulation Inc. "AK FLEX";
 - .3 Johns Manville Inc. Pipe and Tank Insulation "Micro-Flex";
 - .4 Multi-Glass Insulation Ltd. "MULTI-FLEX MF";
 - .5 Owens Corning Pipe and Tank Insulation.
- .3 Semi-Rigid Mineral Wool Blanket
 - .1 Equal to Roxul "Enerwrap MA 960" flexible, black fibrous scrim faced mineral wool blanket insulation to ASTM C553.
- .4 Closed Cell Foamed Glass
 - .1 Pittsburgh Corning "FOAMGLAS" expanded, rigid board and block type insulation with a liquid or vapour permeability rating (in accordance with ASTM C240) of 0.00.

2.6 Removable/Reusable Insulation Covers

- .1 Covers for equipment 12 mm (½") to less than 150 mm (6"):
 - .1 Valve, etc. covers are to be NO SWEAT reusable insulation wraps with vapour barrier jacket and self-sealing ends and longitudinal seam, with a length to suit application and an insulation thickness equal to adjoining insulation.

2.7 Ductwork System Insulation Materials

- .1 Rigid Mineral Fibre Board
 - .1 Pre-formed board type insulation to ASTM C612, 48 kg/m³ (3 lb/ft³) density, with a factory applied reinforced aluminum foil and kraft paper facing.
 - .2 Acceptable products are:
 - .1 Knauf Fiber Glass Insulation Board with FSK facing;
 - .2 Manson Insulation Inc. "AK BOARD FSK";

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- .3 Johns Manville Inc. Type 814 "Spin-Glas";
 - .4 Owens Corning 703.
- .2 Semi-Rigid Mineral Fibre Board
 - .1 Roll form insulation to ASTM C1393, consisting of cut strips of rigid mineral board insulation glued to an aluminium foil and kraft paper facing.
 - .2 Acceptable products are:
 - .1 Multi-Glass Insulation Ltd. "Multi-Flex MKF";
 - .2 Owens Corning Pipe and Tank Insulation;
 - .3 Johns Manville Inc. Pipe and Tank Insulation "Micro-Flex".
- .3 Blanket Mineral Fibre
 - .1 Blanket type roll form insulation to ASTM C553, 24 kg/m³ (1-½ lb/ft³) density, 40 mm (1-½") thick, with a factory applied vapour barrier facing.
 - .2 Acceptable products are:
 - .1 Johns Manville Inc. Microlite FSK Duct Wrap Type 150;
 - .2 Knauf Fiber Glass Blanket Insulation FSK Duct Wrap Type III;
 - .3 Manson Insulation Inc. ALLEY WRAP FSK Duct Wrap Type III;
 - .4 Certainteed Corporation Softtouch FSK Duct Wrap Type 150.
- .4 Flexible Foam Elastomeric
 - .1 Sheet form, CFC free, closed cell, self-adhering elastomeric nitrile rubber insulation with a water vapour permeability rating of 0.08 in accordance with ASTM E96 Procedure A.
 - .2 Acceptable products are:
 - .1 Armacell "AP Armaflex";
 - .2 IK Insulation Group "K-Flex Duct Wrap", S2S.

2.8 Fire Rated Duct Wrap

- .1 Flexible, non-combustible, blanket type mineral fibre duct wrap completely encapsulated in reinforced foil, and suitable for installation with zero clearance to combustibles (for grease ducts), and ULC tested and listed (to category HNKNC) to facilitate a 2 hour fire resistance rating (76 mm [3"] thick) or a 1 hour fire resistance rating (38 mm [1-½"] thick) in accordance with local governing authority.
- .2 Submit FRD design number documentation with shop drawing.
- .3 Acceptable manufacturers are:
 - .1 3M Fire Barrier Duct Wrap 615;
 - .2 CL4 Inc. "CL4Fire";
 - .3 Unifrax Corp. "FyreWrap Elite 1.5";
 - .4 Morgan Thermal Ceramics "FireMaster FastWrap XL".

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2.9 Insulating Coatings

- .1 Equal to Robson Thermal Manufacturing Ltd. insulating coatings as follows:
 - .1 anti-condensation coating, "No Sweat-FX";
 - .2 thermal insulating coating, "ThermaLite".

2.10 Insulation Fastenings

- .1 Wire
 - .1 Minimum #15 gauge galvanized annealed wire.
- .2 Wire with Mesh
 - .1 Minimum #15 gauge galvanized annealed wire factory woven into 25 mm (1") hexagonal mesh.
- .3 Duct Insulation Fasteners
 - .1 Weld-on 2 mm (3/32") diameter zinc coated steel spindles of suitable length, complete with minimum 40 mm (1-1/2") square plastic or zinc plated steel self-locking washers.
- .4 Tape Sealant
 - .1 Equal to 3M 1520-CW self-adhesive insulation tapes, types PAF, FSK, ASJ, or SWV as required to match surface being sealed.
- .5 Mineral Fibre Insulation Adhesive
 - .1 Clear, pressure sensitive, brush consistency adhesive, suitable for a temperature range of -20°C to 82°C (-4°F to 180°F), compatible with type of material to be secured, and WHMIS classified as non-hazardous.
- .6 Flexible Elastomeric Insulation Adhesive
 - .1 Armacell "Armaflex" #520 air-drying contact adhesive.
- .7 Closed Cell Foamed Glass Insulation Adhesive
 - .1 Pittsburgh Corning PC88 multi-purpose 2-component adhesive.
- .8 Lagging Adhesive
 - .1 White, brush consistency, ULC listed and labelled, maximum 25/50 fire/smoke rated in accordance with ULC S102, lagging adhesive for canvas jacket fabric, suitable for colour tinting, complete with fungicide and washable when dry.
- .9 Screws
 - .1 No. 10 stainless steel sheet metal screws.

2.11 Insulation Jackets and Finishes

- .1 Canvas Jacket Material
 - .1 ULC listed and labelled, 25/50 fire/smoke rated, roll form, minimum 170 g (6 oz.).
- .2 Flexible Insulation Jacketing

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- .1 Equal to 3M VentureClad 1577CW Series, flexible, laminated, self-adhering, protective jacketing, vapour barrier with 0.00 permeability rating and weatherproofing membrane, having a high performance acrylic adhesive capable of installation with no additional mechanical attachment and with a maximum flame spread/smoke developed rating of 25/50 when tested in accordance with ULC S102. Review finish colour requirements with Consultant before ordering.
- .3 Roll Form Sheet and Fitting Covers
 - .1 Minimum 15 mm (½") thick white PVC, maximum 25/50 fire/smoke rated tested in accordance with ULC S102, complete with installation and sealing accessories. Acceptable products are:
 - .1 Johns Manville Inc. "Zeston" 300;
 - .2 Proto Corp. "LoSMOKE".
- .4 Rigid Aluminium Jacket
 - .1 Equal to ITW Insulation Systems Canada "Lock-on" 0.406 mm (0.016") thick embossed aluminium jacket material to ASTM B209, factory cut to size and complete with polysurlyn moisture barrier and continuous modified Pittsburgh Z-Lock, butt straps with "Fabstraps" to weatherproof the end to end joints, and 2-piece epoxy coated pressed aluminium fittings with weather locking edges.
- .5 Stainless Steel Jacket
 - .1 Equal to ITW Insulation Systems Canada "Lock-on" 0.254 mm (0.010") thick type 304 embossed stainless steel jacket material to ASTM A240, factory cut to size and complete with moisture barrier and continuous modified Pittsburgh Z-Lock, butt straps with "Fabstraps" to cover end to end joints, and 2-piece pressed stainless steel fittings with weather locking edges.
- .6 Adhesive-Backed Flexible Aluminium
 - .1 MFM Building Products Corp. "Flex-Clad 400" roll form sheet material with an aggressive rubberized asphalt adhesive backing, high density polyethylene reinforcement, and an embossed aluminium facing.

PART 3 - EXECUTION

3.1 General Insulation Application Requirements

- .1 Unless otherwise specified, do not insulate following:
 - .1 factory insulated equipment and piping;
 - .2 heating piping within radiation unit enclosures, including blank filler sections of enclosures;
 - .3 heating piping in soffits and/or overhang spaces and connected to bare element radiation in spaces;
 - .4 branch potable water piping located under counters to serve counter mounted plumbing fixtures and fittings, except barrier-free lavatories;
 - .5 exposed chrome plated potable water angle supplies from concealed piping to plumbing fixtures and fittings, except barrier-free lavatories;

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- .6 heated liquid system pump casings, valves, strainers and similar accessories;
 - .7 heating system expansion tanks;
 - .8 fire protection pump casings;
 - .9 manufactured expansion joints and flexible connections;
 - .10 acoustically lined ductwork and/or equipment;
 - .11 factory insulated flexible branch ductwork;
 - .12 fire protection system water storage tanks;
 - .13 piping unions, except for unions in "cold" category piping.
- .2 Install work generally in accordance with TIAC National Insulation Standards Manual except conform to manufacturer's instructions and recommendations, and requirements specified in this Section.
 - .3 Install insulation directly over pipes and ducts, not over hangers and supports.
 - .4 Install piping insulation and jacket continuous through pipe openings and sleeves.
 - .5 Install duct insulation continuous through walls, partitions, and similar surfaces except at fire dampers.
 - .6 For insulation thicknesses greater than or equal to 75 mm (3"), provide double layer of insulation to achieve required insulation thickness and stagger joint locations.
 - .7 When insulating "cold" piping and equipment, extend insulation up valve bodies and other such projections as far as possible, and protect insulation jacketing from condensation at its junction with metal.
 - .8 Insulate, vapour seal, and finish seismic restraints, braces, anchors, hanger rods, and similar hardware directly connected to "cold" piping and/or equipment, for a distance of 300 mm (12") clear of adjacent pipe or equipment finish, to match piping and/or equipment insulation.
 - .9 When insulating vertical piping risers 75 mm (3") diameter and larger, use insulation support rings welded directly above lowest pipe fitting, and thereafter at 4.5 m (14.7') centres and at each valve and flange. Insulate in accordance with Thermal Insulation Association of Canada National Insulation Standards, Figure No. 9.

3.2 Pipe Insulation Requirements – Mineral Fibre

- .1 Insulate following pipe inside building and above ground with mineral fibre insulation of thickness indicated:
 - .1 domestic cold water piping, less than 100 mm (4") dia. – 25 mm (1") thick;
 - .2 domestic cold water piping, greater than or equal to 100 mm (4") dia. – 40 mm (1½") thick;
 - .3 domestic hot water piping, less than 40 mm (1½") dia. – 25 mm (1") thick;
 - .4 domestic hot water piping, greater than or equal to 40 mm (1½") dia. – 40 mm (1½") thick;
 - .5 tempered domestic water piping, supply and return, less than 40 mm (1½") dia. – 25 mm (1") thick;

Mechanical Insulation

- .6 tempered domestic water piping, supply and return, greater than or equal to 40 mm (1-½") dia. – 50 mm (2") thick;
 - .7 storm drainage piping from roof drains to the point where main vertical risers extend straight down, without offsets, and connect to horizontal underground mains – 25 mm (1") thick;
 - .8 condensate drainage piping from fan coil unit or any other air conditioning system/unit drain pans to main vertical drain risers or to indirect drainage point – 25 mm (1") thick;
 - .9 drainage piping from refrigerated drinking fountains to nearest 75 mm (3") dia. or larger drain pipe – 25 mm (1") thick;
 - .10 chilled water piping, supply and return, less than 100 mm (4") dia. – 25 mm (1") thick;
 - .11 chilled water piping, supply and return, greater than or equal to 100 mm (4") dia. – 40 mm (1-½") thick;
 - .12 chilled glycol solution piping, supply and return, less than 100 mm (4") dia. – 25 mm (1") thick;
 - .13 chilled glycol solution piping, supply and return, greater than or equal to 100 mm (4") dia. – 40 mm (1-½") thick;
 - .14 hot water heating piping, supply and return, less than 40 mm (1-½") dia. – 40 mm (1-½") thick;
 - .15 hot water heating piping, supply and return, greater than or equal to 40 mm (1-½") dia. – 50 mm (2") thick;
 - .16 glycol solution heating or heat reclaim piping, supply and return, less than 40 mm (1-½") dia. – 40 mm (1-½") thick;
 - .17 glycol solution heating or heat reclaim piping, supply and return, greater than or equal to 40 mm (1-½") dia. – 50 mm (2") thick;
 - .18 air compressor set fresh air intake piping – 25 mm (1") thick;
-
- .2 Unless otherwise specified, insulate unions, valves, strainers, and similar piping system accessories in "cold" piping with cut and tightly fitted segments of sectional pipe insulation with joints covered with tape sealant, or, alternatively, wrap piping union, valve, strainer, etc., with blanket mineral fibre and cover with PVC covers as for paragraph above.
 - .3 Terminate sectional insulation approximately 50 mm (2") from flange or coupling on each side of flange or coupling. Cover flange or coupling with a minimum 50 mm (2") thickness of blanket mineral fibre insulation wide enough to butt tightly to ends of adjacent sectional insulation. Secure blanket insulation in place and cover with a purpose made PVC coupling cover.

Mechanical Insulation

- .4 Insulate seismic restraint hardware such as hanger rods, braces, anchors, etc., directly connected to "cold" category piping and equipment for a distance of 300 mm (12") from piping or equipment with insulation and finish to match pipe or equipment insulation. Coat seismic restraint hardware for a distance of 300 mm (12") from the termination of insulation with Robson Thermal "NO-SWEAT-FX" water based anti-condensation coating.

3.3 Pipe Insulation Requirements – Fire-Rated Insulation

- .1 Where pipe (inside building and above ground) which is to be insulated penetrates fire rated construction, provide fire-rated, non-combustible sectional insulation on portion of pipe in fire barrier and for a distance of 50 mm (2") on either side of fire barrier. Insulation thickness is to be as specified, but in any case minimum 25 mm (1").

3.4 Installation of Barrier-Free Lavatory Insulation Kits

- .1 Provide manufactured insulation kits to cover exposed drainage and water piping under barrier-free lavatories.

3.5 Equipment Insulation Requirements – Blanket Type Mineral Fibre

- .1 Insulate following equipment with mineral fibre blanket type insulation of thickness indicated:
 - .1 chilled water and/or domestic cold-water pump casings – 40 mm (1-½") thick;
 - .2 roof drain sumps where inside the building – 25 mm (1") thick;
 - .3 water meter(s) – 40 mm (1-½") thick;
 - .4 top of radiant ceiling panels – 50 mm (2") thick.
- .2 Unless otherwise noted, wrap equipment to a thickness and insulating value equal to an equivalent thickness of rigid sectional pipe insulation. Laminate insulation in place with a full coverage of adhesive and secure with wire. Apply a jacket of insulation vapour barrier material secured in place with adhesive or sealant tape.
- .3 Cover roof drain sumps with purpose made PVC fitting covers.
- .4 Lay fibreglass blanket on radiant ceiling panels after testing is complete.
- .5 For "cold" equipment, prime insulation with suitable sealer and apply a jacket of glass thread reinforced foil and kraft paper vapour barrier jacket material laminated in place with a full coverage of adhesive.
- .6 Provide removable and replaceable insulated metal covers for equipment with removable heads to permit heads to be removed and replaced without damaging adjacent insulation work.
- .7 Provide "wrap type" removable and reusable insulation covers for "cold" circuit balancing valves, backflow preventers, and similar items, and for steam traps and similar items requiring service in piping less than 150 mm (6") dia.

3.6 Ductwork Insulation Requirements – Mineral Fibre

- .1 Insulate following ductwork systems inside building and above ground with mineral fibre insulation of thickness indicated:

Mechanical Insulation

- .1 outside air intake ductwork, casings and plenums from fresh air intakes to and including mixing plenums or sections, or, if mixing plenums or sections are not provided, to first heating coil, or if both mixing plenums or sections and heating coil sections are not provided, and fresh air is not tempered, then the fresh air ductwork system complete – minimum 40 mm (1-½") thick as required;
 - .2 mixed supply air or preheated supply air casings, plenums and sections to and including the fan section where not factory insulated – minimum 25 mm (1") thick rigid board or minimum 40 mm (1-½") thick flexible blanket as required;
 - .3 supply air ductwork outward from fans, except for supply ductwork exposed in area it serves – minimum 25 mm (1") thick rigid board or minimum 40 mm (1-½") thick flexible blanket as required;
 - .4 exhaust discharge ductwork for a distance of 3 m (10') downstream (back) from exhaust openings to atmosphere, including any exhaust plenums within the 3 m (10') distance – minimum 25 mm (1") thick rigid board or minimum 40 mm (1-½") thick flexible blanket as required;
 - .5 any other ductwork, casings, plenums or sections specified or detailed on drawings to be insulated – thickness as specified.
- .2 Provide rigid board type insulation for casings, plenums, and exposed rectangular ductwork. Provide blanket type insulation for concealed round, oval or rectangular ductwork. Provide semi-rigid mineral fibre board type insulation for exposed round or oval ducts.
 - .3 Liberally apply adhesive to surfaces of exposed rectangular ducts and/or casings. Accurately and neatly press insulation into adhesive with tightly fitted butt joints. Provide pin and washer insulation fasteners at 300 mm (12") centres on bottom and side surfaces. Secure and seal joints with 75 mm (3") wide tape sealant. Additional installation requirements as follows:
 - .1 at trapeze hanger locations, install insulation between duct and hanger;
 - .2 provide drywall type metal corner beads on edges of ductwork, casings and plenums in equipment rooms, service corridors, and any other area where insulation is subject to accidental damage, and secure in place with tape sealant.
 - .4 Liberally apply adhesive to surfaces of concealed rectangular or oval ductwork, and wrap insulation around duct with a top butt joint and tight section to section butt joints. Provide pin and washer insulation fasteners at 300 mm (12") centres on bottom surfaces. Secure and seal joints with 75 mm (3") tape sealant. At each trapeze type duct hanger, provide a 100 mm (4") wide full length piece of rigid mineral fibre board insulation between duct and hanger.
 - .5 Accurately cut sections of insulation to fit tightly and completely around exposed and concealed round or oval ductwork. Liberally apply adhesive to surfaces of duct, and wrap insulation around duct with a top butt joint and tight section to section butt joints. Seal joints with tape sealant. At duct hanger locations install insulation between duct and hanger. At each hanger location for concealed ductwork where flexible blanket type insulation is used, provide a 100 mm (4") wide full circumference strip of semi-rigid board type duct insulation between duct and hanger.
 - .6 Insulation application requirements common to all types of rigid ductwork are as follows:

Mechanical Insulation

- .1 at duct connection flanges, insulate flanges with neatly cut strips of rigid insulation material secured with adhesive to side surfaces of flange with a top strip to cover exposed edges of the side strips, then butt the flat surface duct insulation up tight to flange insulation, or, alternatively, increase insulation thickness to depth of flange and cover top of flanges with tape sealant;
- .2 installation of fastener pins and washers is to be concurrent with duct insulation application;
- .3 cut insulation fastener pins almost flush to washer and cover with neatly cut pieces of tape sealant;
- .4 accurately and neatly cut and fit insulation at duct accessories such as damper operators (with standoff mounting) and pitot tube access covers;
- .5 prior to concealment of insulation by either construction finishes or canvas jacket material, patch vapour barrier damage by means of tape sealant.

3.7 Installation of Fire Rated Duct Wrap

3.8 Application of Insulating Coatings

- .1 Apply, in accordance with manufacturer's instruction, insulating coatings to following bare metal surfaces:
 - .1 paint bare metal surfaces clear of "cold" piping and/or equipment insulation for a distance of from 300 mm (12") to 600 mm (24") clear of pipe or equipment insulation, with "No Sweat-FX" anti-condensation coating;
 - .2 paint bare metal surfaces associated with mechanical systems with an operating temperature 60°C (140°F) with "ThermaLite" insulating coating.
- .2 Apply coatings with a brush. Remove any splatter or excess coating from adjacent surfaces.

3.9 Insulation Finish Requirements

- .1 Canvas Jacket Material
 - .1 Unless otherwise shown and/or specified, jacket exposed mineral fibre insulation, and calcium silicate duct insulation work inside building with canvas secured in place with a full covering coat of lagging adhesive. Accurately cut canvas with scissors or a knife. Do not rip or tear canvas to size. Remove lagging adhesive splatter from adjacent uninsulated surfaces.
- .2 Unless otherwise shown or specified, jacket exposed mineral fibre insulation listed below with canvas jacket secured in place with a full covering coat of coloured lagging adhesive. Accurately cut canvas with scissors or a knife. Do not rip or tear canvas to size. Remove lagging adhesive splatter from adjacent surfaces. Flexible Insulation Jacketing
 - .1 Flexible insulation jacketing is to be considered equivalent to canvas and lagging, PVC, and rigid metal jacketing, and may be provided in lieu of aforementioned materials/products. Submit list with shop drawing submittal indicating which services are to be provided with flexible insulation jacketing. For services inside building, ensure product utilized has been tested to CAN/ULC S102 and meets local governing flame spread/smoke developed requirements.

Mechanical Insulation

- .2 Confirm finish/colour with Consultant before ordering.
- .3 Install in accordance with manufacturer's instructions and recommendations.
- .3 PVC Pipe and Fittings Covers
 - .1 Jacket exposed pipe insulation work inside building with white sheet PVC and fitting covers. Install sheet PVC and fitting covers tightly in place with overlapped circumferential and longitudinal joints arranged to shed water. Seal joints to produce a neat, water-tight installation. Provide slip-type expansion joints where required by manufacturer's instructions.
- .4 Rigid Aluminium Jacket
 - .1 Install rigid aluminium jacket material tightly in place with overlapped circumferential joints positioned to shed water and covered with butt straps supplied with jacket. Provide aluminium jacket for following insulation:
- .5 Rigid Stainless Steel Jacket
 - .1 Install rigid stainless steel jacket material tightly in place with overlapped circumferential joints positioned to shed water and covered with butt straps supplied with jacket. Provide stainless steel jacket for following:
- .6 Coating for Closed Cell Foamed Glass Insulation
 - .1 Apply 2 heavy coats of "PITTCOTE 404" coating with 24 hr. between coats to foamed glass insulation exposed above grade.
- .7 Coating for Flexible Foam Elastomeric Insulation
 - .1 Apply 2 coats (with 24 hr. between coats) of specified coating to flexible elastomeric insulation outside building.

END OF SECTION

PART 1 - GENERAL

1.1 Application

- .1 This Section specifies requirements, criteria, methods and execution for mechanical demolition work that are common to one or more mechanical work Sections, and it is intended as a supplement to each Section and is to be read accordingly.

PART 2 - PRODUCTS

NOT USED

PART 3 - EXECUTION

3.1 Disconnection and Removal of Existing Mechanical Work

- .1 Where indicated on drawings, disconnect and remove existing mechanical work, including hangers, supports, insulation, etc. Disconnect at point of supply, remove obsolete connecting services and make system safe. Cut back obsolete piping behind finishes and cap water-tight unless otherwise specified.
- .2 Scope and extent of demolition or revision work is only generally indicated on drawings. Estimate scope, extent and cost of work at site during bidding period site visit(s). Claims for extra costs for demolition work not shown or specified but clearly visible or ascertainable at site during bidding period site visits will not be allowed.
- .3 If any re-design is required due to discrepancies between mechanical drawings and site conditions, notify Consultant who will issue a Site Instruction. If, in the opinion of Consultant, discrepancies between mechanical drawings and actual site conditions are of a minor nature, required modifications are to be done at no additional cost.
- .4 Where existing mechanical services extend through, or are in an area to serve items which are to remain, maintain services in operation. Include for rerouting existing services concealed behind existing finishes and which become exposed during renovation work, so as to be concealed behind new or existing finishes.
- .5

3.2 Hazardous Waste

- .1 Be advised that items such as drainage sumps, catch basins, interceptors, and the like may contain unidentified hazardous waste and caution is to be taken when disconnecting and removing these items.

3.3 If hazardous waste not listed in Specification is found, notify Owner and Consultant immediately and await directions. Interruption to and Shut-Down of Mechanical Services and Systems

- .1 Co-ordinate shut-down and interruption to existing mechanical systems with Owner. Generally, shut-downs may be performed only between the hours of 12:00 midnight Friday until 6:00 a.m. Monday morning.
- .2 Upon award of contract, submit a list of anticipated shut-down times and their maximum duration.

Demolition and Revision Work

- .3 Prior to each shut-down or interruption, inform Owner in writing 5 business days in advance of proposed shut-down or interruption and obtain written consent to proceed. Do not shut-down or interrupt any system or service without such written consent.
- .4 Perform work associated with shut-downs and interruptions as continuous operations to minimize shut-down time and to reinstate systems as soon as possible, and, prior to any shut-down, ensure materials and labour required to complete the work for which shut-down is required are available at site.
- .5 Pipe freezing may be used to connect new piping to existing piping without draining existing piping. Pipe freeze equipment is to be equal to "NORDIC FREEZE" equipment supplied by Mag Tool Inc. or Rigid Tool Co. RIGID "SuperFreeze".

END OF SECTION

Mechanical Work Commissioning

PART 1 - GENERAL

1.1 Application

- .1 This Section specifies commissioning requirements that are common to Mechanical Divisions work Sections and it is a supplement to each Section and is to be read accordingly. When requirements of this Section contradict requirements of Divisions 00 or 01, conditions of Divisions 00 or 01 to take precedence.

1.2 Reference

- .1 Refer to commissioning requirements specified in Division 01.

1.3 Commissioning Agent Involvement Versus Warranty Obligations

- .1 Involvement of Commissioning Agent performing duties as described in this Section is not in any way to void or alter any Contractual warranty obligations.

1.4 Submittals

- .1 Submit to Commissioning Agent, at same time as submittal to Consultant, one copy of each shop drawing or product data sheet associated with equipment or systems to be commissioned.
- .2 Submit for review, a Commissioning Plan with schedule, commissioning procedures for commissioning events, and a copy of Commissioning Agent's commissioning data sheets for equipment/systems to be commissioned.
- .3 Submit a list of commissioning instruments and for each instrument, indicate purpose of instrument and include a recent calibration certificate.
- .4 Submit equipment and system manufacturer's start-up and test report sheets for review a minimum of 1 month prior to equipment and system start-up procedures.
- .5 After start-up and successful pre-functional performance testing and submittal of completed forms, submit, for each system or subsystem, a letter confirming pre-functional performance testing has been successfully completed and system or subsystem is ready for functional performance testing and commissioning process to commence.

1.5 Definitions

- .1 Commissioning: process of demonstrating to Owner and Consultant, for purpose of final acceptance, by means of successful and documented functional performance testing, that systems and/or subsystems are capable of being operated and maintained to perform in accordance with requirements of Contract Documents, all as further described below.
- .2 Commissioning Agent: commissioning authority who will supervise commissioning process, and who will recommend final acceptance of commissioned mechanical work.

Mechanical Work Commissioning

- .3 Start-Up and Adjusting: process of equipment manufacturer's/supplier's technical personnel, with Contractor, starting and operating equipment and systems, making any required adjustments, documenting process, and submitting manufacturer's/supplier's start-up reports to confirm equipment has been properly installed and is operational as intended.
- .4 Pre-Functional Performance Testing: testing, adjusting and operating of components, equipment, systems and/or subsystems, by Contractor, after start-up but before functional performance testing, to confirm components, equipment, systems and/or subsystems operate in accordance with requirements of Contract Documents, including modes and sequences of control and monitoring, interlocks, and responses to emergency conditions, and including submittal of pre-functional performance testing documentation sheets.
- .5 Functional Performance Testing: a repeat of successful pre-functional performance testing by Contractor, in presence of Commissioning Agent and Consultant with completed Commissioning Agent's commissioning documentation sheets to document, validate and verify equipment, systems and subsystems are complete in all respects, function correctly, and are ready for acceptance.
- .6 Commissioning Documentation Sheets: prepared sheets for pre-functional performance testing and for functional performance testing supplied by Commissioning Agent for each piece of equipment/system to be commissioned, each sheet or set of sheets complete with Project name and number, date of commissioning, equipment/system involved, equipment/system name and model number, equipment tag in accordance with drawings, and, for each commissioning procedure listed, a column giving expected data in accordance with Contract Documents, a column to fill in observed data during commissioning, and space for signatures of Contractor and Commissioning Agent.
- .7 Systems Operating Manual: a manual prepared by Commissioning Agent to present an overview of building mechanical systems and equipment to be used by building maintenance personnel to assist them in daily operation of systems.
- .8 Validate: to confirm by examination and witnessing tests correctness of equipment and system operation.

1.6 Commissioning Agent

- .1 Retain services of a qualified Commissioning Agent.

1.7 Quality Assurance

- .1 Commissioning work is to be in accordance with requirements of following:
 - .1 CSA Z320, Building Commissioning Standard and Check Sheets;
 - .2 CSA Z8001, Commissioning of Health Care Facilities;
 - .3 ASHRAE Guideline 0, The Commissioning Process;
 - .4 ASHRAE Guideline 1.1, The HVAC Commissioning Process;
 - .5 ASHRAE Guideline 1.2, The Commissioning Process for Existing HVAC&R Systems;
 - .6 ASHRAE Guideline 1.5, Commissioning Smoke Control Systems;
 - .7 Owner designated Commissioning Agent.

Mechanical Work Commissioning

.2 Commissioning Agent is to meet following qualifications:

- .1 be a member of Professional Engineers Association in Province of the work;
- .2 be a member of Building Commissioning Association, and a Certified Commissioning Professional (CCP) as designated by Building Commissioning Association;
- .3 have a minimum of 5 years of successful documented commissioning experience on projects of similar size and complexity as this Project;
- .4 supply a qualified P. Eng. and a Building Commissioning Association Certified Commissioning Professional (CCP) or an ASHRAE Commissioning Project Management Professional (CPMP) on site to supervise commissioning process.

1.8 Commissioning Objectives

.1 Objectives of commissioning process:

- .1 to support quality management by means of monitoring and checking installation;
- .2 to verify equipment/system performance by means of commissioning of completed installation;
- .3 to move completed equipment/systems from "static completion" state to "dynamic" operating state so as to transfer a complete and properly operating installation from Contractor to Owner.

1.9 Testing Equipment

- .1 Supply instruments and test equipment required to conduct start-up, testing and commissioning procedures.

PART 2 - PRODUCTS

NOT USED

PART 3 - EXECUTION

3.1 Commissioning

- .1 Commission work in accordance with requirements of this Section and as required by Commissioning Agent.
- .2 Prerequisites to successful completion of commissioning:
 - .1 submittal of signed start-up and test reports;
 - .2 completion of system testing, adjusting and balancing (TAB), and acceptance of TAB reports;
 - .3 permanent electrical and control connections of equipment;
 - .4 successful completion and documentation of pre-functional performance testing;
 - .5 submittal of letters to Consultant certifying systems and subsystems have been started, tested, adjusted, successfully pre-functional performance tested, are ready for functional performance testing, and are in accordance with requirements of Contract Documents.

Mechanical Work Commissioning

3.2 Phasing of Commissioning

- .1 Project will be constructed in phases as described in Specification. Phase commissioning to suit progress and phases of Work.

3.3 Deficiencies Listed During Commissioning

- .1 Correct deficiencies listed by Consultant and Commissioning Agent during commissioning process within 15 calendar days of notification unless agreed otherwise with Consultant, and when deficiencies have been corrected, notify Consultant and Commissioning Agent immediately.

3.4 Systems to be Commissioned

- .1 Mechanical systems to be commissioned include, but are not to be limited to, systems described below. Specific commissioning procedures are to be as directed by Commissioning Agent.
- .2 Commissioning of drainage systems includes:
 - .1 commissioning of drainage pumps and controls by means of tests recommended by manufacturer to confirm proper operation and performance;
 - .2 commissioning of equipment such as interceptors and backflow preventers.
- .3 Commissioning of fire protection systems will be considered complete upon preparation and submittal by Contractor of completion certificates required by applicable NFPA Standards, demonstration of proper system operation to local Fire Chief and any other authorities, including Owner's insurance underwriter as required, and coordination and cooperation with fire alarm system commissioning procedures, in particular smoke control systems and other such fan system control sequences.
- .4 Commissioning of water systems (all piping extended from Municipal main) includes:
 - .1 commissioning of pumps and controls;
 - .2 commissioning of water heaters;
 - .3 commissioning of piping specialties such as backflow preventers, mixing valves, and similar components;
 - .4 commissioning of trap seal primer units, including adjustment of water flows and confirmation of water flow at each connected trap;
 - .5 commissioning of plumbing fixtures.
- .5 Commissioning of swimming pool systems includes pool piping and fittings, pumping equipment and controls, filtering equipment, and chemical treatment equipment, as well as any specialized equipment for pool area such as dehumidifiers.
- .6 Commissioning of laboratory systems includes piping, fittings including bench work fittings, and associated equipment including special ventilation systems.
- .7 Commissioning of medical gas systems is not part of mechanical commissioning work and will be done as part of work specified in the Section entitled Medical Gas Piping Systems.
- .8 Commissioning of compressed air system includes "head end" compressor equipment, pressure reducing equipment, and outlets.

Mechanical Work Commissioning

- .9 Commissioning of natural gas system includes pressure regulating equipment. Perform commissioning in accordance with requirements of CAN/CSA B149.1, and any supplemental requirements of governing authorities.
- .10 Commissioning of propane gas system includes pressure regulating equipment. Perform commissioning in accordance with requirements of CAN/CSA B149.2, and any supplemental requirements of governing authorities.
- .11 Perform commissioning of fuel oil system in accordance with requirements of CAN/CSA B139.
- .12 Commissioning of heating systems includes piping, piping specialties, equipment, and control, as well as checking and validating temperature and flow documentation contained in TAB reports. If TAB is not done during heating season, a follow-up site visit during heating season will be required to confirm proper flows and temperatures, and any required system "fine tuning".
- .13 Commissioning of cooling systems includes piping, piping specialties, equipment, and control, as well as checking and validating temperature and flow documentation contained in TAB reports. If TAB is not done during cooling season, a follow-up site visit during cooling season will be required to confirm proper flows and temperatures, and any required system "fine tuning".
- .14 Commissioning of HVAC chemical treatment systems includes feed and monitoring equipment, and testing of system fluids to confirm proper concentration of chemical.
- .15 Commissioning of air handling systems includes equipment, ductwork, ductwork specialties, controls, interlocks, and checking and validating air capacities and flows in accordance with TAB reports.
- .16 Control work commissioning includes confirmation of proper operation of individual control components, and overall operation of controls in conjunction with operation of connected building systems, including heating season/cooling season testing requirements specified above.
- .17 Commissioning of BAS includes confirmation of proper operation of components, input/output points, hardware and software, and demonstration of system performing required procedures.
- .18 Commissioning of special usage room controls includes confirmation of proper operation of individual components, and proper operation of overall control system, all in accordance with governing Codes and Standards.
- .19 Commissioning of noise and vibration control equipment includes noise and vibration measurements to confirm proper operation of equipment.

3.5 Commissioning Process

- .1 Perform commissioning process in stages and include, but not be limited to, following:
 - .1 Stage 1: Commissioning of equipment/systems as listed in this Section, which is a prerequisite to an application for Substantial Performance of the Work and includes supervising and validating results of functional performance testing, and submittal of reviewed Systems Operating Manual.

Mechanical Work Commissioning

- .2 Stage 2: Commissioning work performed 12 months after issue of a Certificate of Substantial Performance and which includes supervision of Contractor's "fine tuning" of equipment/systems through seasonal occupancy, and any other such work to achieve optimal comfort and performance conditions.
- .3 Stage 3: Successful completion of satisfactory equipment/system operation during 1st month after issue of a Certificate of Total Performance of the Work.
- .4 Stage 4: Successful completion of satisfactory equipment/system operation during 3rd month after issue of a Certificate of Total Performance of the Work.
- .5 Stage 5: Successful seasonal commissioning of building.

3.6 Responsibilities of Commissioning Agent

- .1 During construction phase, Commissioning Agent is to:
 - .1 review Contractor's shop drawings for commissioning related issues, and report any such issues to Consultant;
 - .2 as soon as possible after project start-up, prepare and issue a Commissioning Plan based on Contractor's construction schedule;
 - .3 prior to tests, supply pre-functional performance test commissioning data sheets for equipment and systems to be commissioned to Contractor;
 - .4 monitor and inspect installation on a regular basis throughout construction stages, issue reports identifying any issues which may have an impact on commissioning process, and work with project team to expeditiously resolve any problems that may arise due to site conditions;
 - .5 arrange with Contractor for on-site commissioning meetings on an as-required basis, to be attended by Contractor and applicable subcontractors, Owner, and Consultant, chair meetings, and prepare and distribute meeting minutes to attendees;
 - .6 witness and validate tests, identify deficiencies, and issue progress reports;
 - .7 coordinate commissioning scheduling with Contractor;
 - .8 review final TAB report on site with Contractor, and check 100% of TAB results for fan equipment, 30% of TAB results for duct systems outward from fan equipment, and issue a report to Consultant;
 - .9 for smaller multiple items of equipment such as air terminal boxes, fan coil units, backflow preventers, and similar equipment, review completed commissioning data sheets submitted by Contractor and review data sheet information on-site with Contractor for 30% of quantity of each item of equipment;
 - .10 review pre-functional performance test commissioning data sheets submitted by Contractor, then witness and supervise functional performance testing and supervise and direct commissioning process, validate commissioning procedures, witness completion of commissioning data sheets by Contractor, and sign completed data sheets;
 - .11 perform a preliminary review of Contractor's O & M Manuals, before they are issued to Consultant, and issue any comments to Consultant;

Mechanical Work Commissioning

- .12 coordinate, with Contractor and Owner, training and instructions by Contractor and his equipment and system manufacturers/suppliers to Owner's operating and maintenance personnel, and comment on quality of training and instructions to Consultant;
- .13 prepare and issue Systems Operation Manual to Owner prior to equipment and system training by Contractor.
- .2 During post construction phase, Commissioning Agent is to:
 - .1 prepare and issue final report on commissioning, identifying any deficiencies that remain outstanding;
 - .2 recommend any training and/or instructions to be given to Owner's operating and maintenance personnel in addition to training and instructions already given;
 - .3 after Substantial Performance of the Work, witness system checks and validate documentation by Contractor as follows:
 - .1 once during 1st month of building operation;
 - .2 once during 3rd month of building operation;
 - .3 once between 4th and 10th month of building operation but during a season opposite to 1st or 3rd month visits.
 - .4 ensure any deficient work resulting from system checks described above are corrected;
 - .5 3 months after Substantial Performance of the Work, attend a question and answer session(s) with Contractor to answer any questions and concerns related to commissioning work from Owner's operating personnel.

3.7 Responsibilities of Contractor

- .1 During construction phase, Contractor is to:
 - .1 prepare and submit an installation schedule which includes a time schedule for each activity with lead and lag time allowed and indicated, shop drawing and working detail drawing submissions, and major equipment factory testing and delivery dates;
 - .2 prepare and submit a commissioning schedule which is to include a time schedule coordinated with installation schedule referred to above and Commissioning Agent, and allowances for additional time for re-tests as may be required, and update schedule on a monthly basis as required;
 - .3 when requested by Commissioning Agent, arrange site commissioning meetings with Owner, Consultant, and applicable subcontractors present, to be chaired by Commissioning Agent who will also prepare and distribute meeting minutes;
 - .4 promptly correct reported deficient work, and report when corrective work is complete;
 - .5 where required by Codes and/or Specification, retain equipment manufacturers/suppliers or independent 3rd parties to certify correct installation of equipment/systems;

Mechanical Work Commissioning

- .6 under supervision of equipment manufacturers/suppliers, start-up and adjust equipment to design requirements, and submit start-up sheets which include equipment data such as manufacturer and model number, serial number where applicable, and performance parameters, all signed by equipment manufacturer/supplier and Contractor;
 - .7 complete Commissioning Agent's commissioning data sheets for multiple items of smaller equipment such as air terminal boxes, fan coil units, backflow preventers, etc., submit sheets to Commissioning Agent, accompany Commissioning Agent for an on-site check of 30% of data sheet information for each type of equipment, and perform any corrective action required as a result of site checks;
 - .8 perform system testing, adjusting and balancing and, when complete, issue a copy of final report to Commissioning Agent for review and a site check of results, and perform any corrective work required as a result of site checks by Commissioning Agent;
 - .9 in accordance with updated commissioning schedule and actual progress at site, certify in writing to Consultant and Commissioning Agent that equipment and/or systems are complete, have been checked, started and adjusted, successfully pre-functional performance tested and documented, and are ready for functional performance testing and commissioning procedures, giving Consultant and Commissioning Agent a minimum of 5 working days' notice;
 - .10 perform system and subsystem functional performance testing under supervision of Commissioning Agent, and submit to Consultant and Commissioning Agent, completed and signed functional performance testing and commissioning data sheets (issued by Commissioning Agent) and also signed by Commissioning Agent.
- .2 During post construction phase, Contractor is to:
- .1 optimize system operation in accordance with building occupant's needs and comments using System Operation Manual prepared by Commissioning Agent as reference;
 - .2 complete commissioning procedures, activities, and performance verification procedures that were delayed or not concluded during construction phase;
 - .3 accompanied by Commissioning Agent, complete system checks and "fine tuning" with signed documentation as follows:
 - .1 once during 1st month of building operation;
 - .2 once during 3rd month of building operation;
 - .3 once between 4th and 10th months in a season opposite to 1st and 3rd month visits.
 - .4 correct deficiencies revealed by system checks described above, and, where required, involve equipment manufacturers/suppliers during corrective actions, and report completion of corrective work;

Mechanical Work Commissioning

- .5 3 months after Substantial Completion conduct a question and answer session(s) at building with Owner's operating and maintenance personnel, with duration of session(s) dictated by number of questions and concerns that have to be addressed.

END OF SECTION

PART 1 - GENERAL

1.1 Application

- .1 This Section specifies mechanical system testing, adjusting, and balancing requirements that are common to mechanical work Sections of the Specification and it is a supplement to each Section and is to be read accordingly.

1.2 Definitions

- .1 "Agency" – means agency to perform testing, adjusting and balancing work.
- .2 "TAB" – means testing, adjusting and balancing to determine and confirm quantitative performance of equipment and systems and to regulate specified fluid flow rate and air patterns at terminal equipment, e.g., reduce fan speed, throttling, etc.
- .3 "hydronic systems" – includes heating water, chilled water, glycol-water solution, condenser water, and any similar system.
- .4 "air systems" – includes outside air, supply air, return air, exhaust air, and relief air systems.
- .5 "flow rate tolerance" – means allowable percentage variation, minus to plus, of actual flow rate values in Contract Documents.
- .6 "report forms" – means test data sheets arranged for collecting test data in logical order for submission and review, and these forms, when reviewed and accepted, should also form permanent record to be used as basis for required future testing, adjusting and balancing.
- .7 "terminal" – means point where controlled fluid enters or leaves the distribution system, and these are supply inlets on water terminals, supply outlets on air terminals, return outlets on water terminals, and exhaust or return inlets on air terminals such as registers, grilles, diffusers, louvers, and hoods.
- .8 "main" – means duct or pipe containing system's major or entire fluid flow.
- .9 "submain" – means duct or pipe containing part of the systems' capacity and serving 2 or more branch mains.
- .10 "branch main" – means duct or pipe servicing 2 or more terminals.
- .11 "branch" – means duct or pipe serving a single terminal.

1.3 Submittals

- .1 Within 30 days of work commencing at site, submit name and qualifications of proposed testing and balancing agency in accordance with requirements of article entitled Quality Assurance below.
- .2 Submit sample test forms, if other than those standard forms prepared by Associated Air Balance Council (AABC) or National Environmental Balancing Bureau (NEBB), are proposed for use.

Testing, Adjusting and Balancing

- .3 Submit a report by Agency to indicate Agency's evaluation of mechanical drawings with respect to service routing and location or lack of balancing devices. Include set of drawings used and marked-up by Agency to prepare report.
- .4 Submit a report by Agency after each site visit made by Agency during construction phase of this Project.
- .5 Submit a draft report, as specified in Part 3 of this Section.
- .6 Submit a final report, as specified in Part 3 of this Section.
- .7 Submit a testing and balancing warranty as specified in Part 3 of this Section.
- .8 Submit reports listing observations and results of post construction site visits as specified in Part 3 of this Section.

1.4 Quality Assurance

- .1 Employ services of an independent testing, adjusting, and balancing agency meeting qualifications specified below, to be single source of responsibility to test, adjust, and balance building mechanical systems to produce design objectives. Agency is to have successfully completed testing, adjusting and balancing of mechanical systems for a minimum of 5 projects similar to this Project within past 3 years, and is to be certified as an independent agency in required categories by one of following:
 - .1 AABC - Associated Air Balance Council;
 - .2 NEBB - National Environmental Balancing Bureau.
- .2 Testing, adjusting and balancing of complete mechanical systems is to be performed over entire operating range of each system in accordance with 1 of following publications:
 - .1 National Standards for a Total System Balance published by Associated Air Balance Council;
 - .2 Procedural Standards for Testing, Adjusting and Balancing of Environmental Systems published by National Environmental Balancing Bureau;
 - .3 Chapter 37, Testing, Adjusting, and Balancing of ASHRAE Handbook HVAC Applications.

PART 2 - PRODUCTS

2.1 Not Used.

PART 3 - EXECUTION

3.1 Scope of Work

- .1 Perform total mechanical systems testing, adjusting, and balancing. Requirements include measurement and establishment of fluid quantities of mechanical systems as required to meet design specifications and comfort conditions, and recording and reporting results.
- .2 Mechanical systems to be tested, adjusted and balanced include:

Testing, Adjusting and Balancing

- .1 TAB of domestic water systems (all piping extended from Municipal main) is to include:
 - .1 domestic hot water recirculation piping;
 - .2 tempered water piping flows.
- .2 TAB of medical gas systems is not part of TAB work and is specified in Section entitled Medical Gas Piping Systems.
- .3 TAB of heating systems is to include piping and equipment fluid temperatures, flows and control, and if TAB is not done during heating season, a follow-up site visit during heating season will be required to confirm proper flows and temperatures, and any required system "fine tuning".
- .4 TAB of cooling systems is also to include piping and equipment fluid temperatures, flows and control, and if TAB is not done during cooling season, a follow-up site visit during cooling season will be required to confirm proper flows and temperatures, and any required system "fine".
- .5 TAB of air handling systems is to include equipment and ductwork air temperatures, capacities and flows.
- .6 Following existing systems, revised as part of mechanical work, are to be tested, adjusted and balanced as for new systems:
 - .1 ;AHU - ACS 1F
 - .2 .AHU – ACS 4F
 - .3 RF – 4F

3.2 Testing, Adjusting and Balancing

- .1 Conform to following requirements:
 - .1 as soon as possible after award of Contract, Agency is to carefully examine a white print set of mechanical drawings with respect to routing of services and location of balancing devices, and is to issue a report listing results of the evaluation;
 - .2 set of drawings examined by Agency is to be returned with evaluation report, with red line mark-ups to indicate locations for duct system test plugs, and required revision work such as relocation of balancing devices and locations for additional devices;
 - .3 after review of mechanical work drawings and specification, Agency is to visit site at frequent, regular intervals during construction of mechanical systems, to observe routing of services, locations of testing and balancing devices, workmanship, and anything else that will affect testing, adjusting and balancing;
 - .4 after each site visit, Agency is to report results of site visit indicating date and time of visit, and detailed recommendations for any corrective work required to ensure proper adjusting and balancing;
 - .5 testing, adjusting and balancing is not to begin until:

Testing, Adjusting and Balancing

- .1 building construction work is substantially complete and doors have been installed;
- .2 mechanical systems are complete in all respects, and have been checked, started, adjusted, and then successfully performance tested.
- .6 mechanical systems to be tested, adjusted and balanced are to be maintained in full, normal operation during each day of testing, adjusting and balancing;
- .7 obtain copies of reviewed shop drawings of applicable mechanical plant equipment and terminals, and temperature control diagrams and sequences;
- .8 Agency is to walk each system from system "head end" equipment to terminal units to determine variations of installation from design, and system installation trades will accompany Agency;
- .9 Agency is to check valves and dampers for correct and locked position, and temperature control systems for completeness of installation before starting equipment;
- .10 wherever possible, Agency is to lock balancing devices in place at proper setting, and permanently mark settings on devices;
- .11 for belt-driven equipment, Agency is to report to Commissioning Agent who in turn is to inform Contractor and Consultant of any situation where sheaves have to be replaced to suit testing and balancing, and replacements are to be done by Contractor at no cost;
- .12 Agency is to leak test ductwork as specified in Section entitled HVAC Air Distribution in accordance with requirements of SMACNA "HVAC Air Duct Leak Test Manual", coordinate work with work of aforementioned Sections, provide detailed sketch(es) to Sheet Metal Contractor and Consultant identifying ductwork not in accordance with acceptable leakage values specified in aforementioned Sections, and retest corrected ductwork;
- .13 Agency is to balance systems with due regard to objectionable noise which is to be a factor when adjusting fan speeds and performing terminal work such as adjusting air quantities, and should objectionable noise occur at design conditions, Agency is to immediately report problem and submit data, including sound readings, to permit an accurate assessment of noise problem to be made;
- .14 Agency is to check supply air handling system mixing plenums for stratification, and where variation of mixed air temperature across coils is found to be in excess of $\pm 5\%$ of design requirements, Agency is to report problem and issue a detail sketch of plenum baffle(s) required to eliminate stratification;
- .15 Agency is to perform testing, adjusting and balancing to within $\pm 5\%$ of design values, and make and record measurements which are within $\pm 2\%$ of actual values;
- .16 for air handling systems equipped with air filters, test and balance systems with simulated 50% loaded (dirty) filters by providing a false pressure drop;

Testing, Adjusting and Balancing

- .17 test, adjust and balance air conditioning systems during summer season and heating systems during winter season, including at least a period of operation at outside conditions within 2.8°C (5°F) wet bulb temperature of maximum summer design condition, and within 5.5°C (10°C) dry bulb temperature of minimum winter design condition, and take final temperature readings during seasonal operation.
- .2 Prepare reports as indicated below.
 - .1 Upon completion of testing, adjusting, and balancing procedures, prepare draft reports on AABC or NEBB forms. Draft reports may be hand written, but must be complete, factual, accurate, and legible. Organize and format draft reports in same manner specified for final reports. Submit 2 complete sets of draft reports. Only 1 complete set of draft reports will be returned.
 - .2 Upon verification and approval of draft reports, prepare final reports, type written, and organized and formatted as specified below. Submit 2 complete sets of final reports. Use units of measurement (SI or Imperial) as used on Project Documents.
 - .3 Report forms are to be those standard forms prepared by the referenced standard for each respective item and system to be tested, adjusted, and balanced. Bind report forms complete with schematic systems diagrams and other data. Provide each as separate electronic files grouped by the following systems:
 - .1 General Information and Summary;
 - .2 Air Systems;
 - .3 Hydronic Systems;
 - .4 Temperature Control Systems;
 - .5 Special Systems.
 - .4 Agency is to provide following minimum information, forms and data in report:
 - .1 inside cover sheet to identify Agency, Contractor, and Project, including addresses, and contact names and telephone numbers and a listing of instrumentation used for procedures along with proof of calibration;
 - .2 remainder of report is to contain appropriate forms containing as a minimum, information indicated on standard AABC or NEBB report forms prepared for each respective item and system;
 - .3 Agency is to include for each system to be tested, adjusted and balanced, a neatly drawn, identified (system designation, plant equipment location, and area served) schematic "as-built" diagram indicating and identifying equipment, terminals, and accessories;
 - .4 Agency is to include report sheets indicating building comfort test readings for all rooms.

Testing, Adjusting and Balancing

- .3 After final testing and balancing report has been submitted, Agency is to visit site with Contractor and Consultant to spot check results indicated on balancing report. Agency is to supply labour, ladders, and instruments to complete spot checks. If results of spot checks do not, on a consistent basis, agree with final report, spot check procedures will stop and Agency is to then rebalance systems involved, resubmit final report, and again perform spot checks with Contractor and Consultant.
- .4 When final report has been accepted, Contractor is to submit to Owner, in name of Owner, a certificate equal to AABC National Guaranty Certification or a NEBB Quality Assurance Program Bond, and in addition, Contractor is to submit a written extended warranty from Agency covering one full heating season and one full cooling season, during which time any balancing problems which occur, with exception of minor revision work done during scheduled site visits, will, at no cost, be investigated by Agency and reported on to Owner, and if it is determined that problems are a result of improper testing, adjusting and balancing, they are to be immediately corrected without additional cost to Owner.
- .5 After acceptance of final report, Agency is to perform post testing and balancing site visits in accordance with following requirements:
 - .1 post testing and balancing site visits are to be made:
 - .1 once during first month of building operation;
 - .2 once during third month of building operation;
 - .3 once between fourth and tenth months in a season opposite to first and third month visit.
 - .2 during each return visit and accompanied by Owner's representative, Agency is to spot rebalance terminal units as required to suit building occupants and eliminate complaints;
 - .3 Agency is to schedule each visit with Contractor and Owner, and inform Consultant;
 - .4 after each follow-up site visit, Agency is to issue to Contractor and Consultant a report indicating any corrective work performed during visit, abnormal conditions and complaints encountered, and recommended corrective action.

END OF SECTION

Firestopping and Smoke Seal Systems

PART 1 - GENERAL

1.1 Application

- .1 This Section specifies material requirements for firestopping and smoke seal systems that are common to mechanical work Sections and it is a supplement to each Section and is to be read accordingly.

1.2 Submittals

1.3 Quality Assurance

- .1 Applicator is to have a minimum of 3 years of successful experience on projects of similar size and complexity, and applicator's qualifications are to be submitted to Consultant for review.
- .2 Installer to be manufacturer trained and certified on specific product. Submit copy of certificate with shop drawings.
- .3 Comply with firestopping and smoke seal product manufacturer's recommendations regarding suitable environment conditions for product installation.

PART 2 - PRODUCTS

2.1 Firestopping and Smoke Seal System Materials

- .1 Asbestos-free, elastomeric materials and intumescent materials, tested, listed and labelled by ULC in accordance with CAN/ULC S115, and CAN/ULC S101 for installation in ULC designated firestopping, and smoke seal systems to provide a positive fire, water and smoke seal and a fire resistance rating (flame, hose stream and temperature) no less than fire rating for surrounding construction.
- .2 Firestopping and smoke seal material system to be specifically ULC certified with designated reference number for its specific installation. As part of shop drawing submission, submit copies of firestopping drawings with ULC certificate and system number for each specific installation.
- .3 Smoke and fire seal materials and manufacturers must be specifically approved for each application of penetrated surfaces, as approved by FM Global and listed in FM Global Approval Guide. Listed companies herein and other manufacturers are only acceptable if compliant with these requirements. As part of shop drawing submission, submit copies of firestopping drawings with FM Global Approval Guide.
- .4 Materials are to be compatible with abutting dissimilar materials and finishes and complete with primers, damming and back-up materials, supports, and anchoring devices in accordance with firestopping manufacturer's recommendations and ULC tested assembly. Coordinate material requirements with trades supplying abutting areas of materials.
- .5 Submit schedule of opening locations and sizes, penetrating items, and required listed design numbers to seal openings to maintain fire resistance ratings.

Firestopping and Smoke Seal Systems

- .6 Typically, for openings of up to 250 mm (10") in diameter, provide putty pad type firestop materials equivalent to Specified Technologies Inc. "SpecSeal" intumescent, non-hardening, water resistant putties containing no solvents, inorganic fibres or silicone compounds.
- .7 Typically, for openings of greater than 250 mm (10") in diameter, and for rectangular openings, provide pillow type firestop materials equivalent to Specified Technologies Inc. "SpecSeal" re-enterable, non-curing, mineral fibre core encapsulated on six sides with intumescent coating contained in a flame retardant poly bag.
- .8 Pipe insulation forming part of a fire and smoke seal assembly is specified in Section entitled Mechanical Insulation.

PART 3 - EXECUTION

3.1 Installation of Firestopping and Smoke Seal Materials

- .1 Where work penetrates or punctures fire rated construction, provide ULC certified, listed and labelled firestopping and smoke sealing packing material systems to seal openings and voids around and within raceway and to ensure that continuity and integrity of fire separation is maintained. Openings not in immediate vicinity of working areas are to be firestopped and sealed same day as being opened.
- .2 Install firestopping and smoke seal materials for each installation in strict accordance with specific ULC certification number and manufacturer's instructions. Comply with local governing building code requirements and obtain approvals from local building inspection department. Ensure openings through fire separations do not exceed maximum size wall opening, and maximum and minimum dimensions indicated in ULC Guide No. 40 U19 for Service Penetration Assemblies and firestopping materials.
- .3 Ensure continuity and integrity of fire separation is maintained and conform to requirements of latest edition of ULC publication "List of Equipment and Materials, Volume II, Building Construction".
- .4 Comply with following requirements:
 - .1 Examine substrates, openings, voids, adjoining construction and conditions under which firestop and smoke seal system is to be installed. Confirm compatibility of surfaces.
 - .2 Verify penetrating items are securely fixed and properly located with proper space allowance between penetrations and surfaces of openings.
 - .3 Report any unsuitable or unsatisfactory conditions to Consultant in writing, prior to commencement of work. Commencement of work will mean acceptance of conditions and surfaces.
 - .4 Mask where necessary to avoid spillage and over coating onto adjoining surfaces. Remove stains on adjacent surfaces.
 - .5 Prime substrates in accordance with product manufacturer's written instructions.
 - .6 Provide temporary forming as required and remove only after materials have gained sufficient strength and after initial curing.
 - .7 Tool or trowel exposed surfaces to a neat, smooth, and consistent finish.
 - .8 Remove excess compound promptly as work progresses and upon completion.

Firestopping and Smoke Seal Systems

- .9 At fusible link damper locations, seal perimeter of angle iron framing on both sides of wall or slab with ULC listed and labelled sealant materials to provide a positive smoke seal.
- .5 Notify Consultant when work is complete and ready for inspection, and prior to concealing or enclosing firestopping and smoke seal materials and service penetration assemblies. Arrange for final inspection of work by local governing authority inspector prior to concealing or enclosing work. Make any corrections required.
- .6 On completion of firestopping and smoke sealing installation, submit a Letter of Assurance to Consultant certifying firestopping and smoke sealing installation has been carried out throughout the building to service penetrations and installation has been performed in strict accordance with requirements of local governing building code, any applicable local municipal codes, ULC requirements, and manufacturer's instructions.
- .7 Manufacturer's authorized representative to inspect and verify each installation and provide a test report signed by installing trade and manufacturer's representative. Test report to list each installation and respective ULC certification and number.
- .8 Where work requires removal of existing firestopping materials and replacement of firestopping materials after changes have been made, ensure replacement material is same material and manufacturer of existing if any remains in place, or ensure all existing material is removed before installation of replacement material.

END OF SECTION

Fire Protection Standpipe System

PART 1 - GENERAL

1.1 Submittals

- .1 Submit shop drawings/product data sheets to regulatory authority for review and approval prior to submitting to Consultant. Conform to following requirements:
 - .1 submit shop drawings/product data sheets for products specified in this Section except pipe and fittings;
 - .2 submit complete CAD layout drawings indicating source of water supply with test flow and pressure, "head-end" equipment piping schematic, pipe routing and sizing, and risers, all signed and sealed by a qualified professional mechanical engineer registered in the jurisdiction of the work as specified below;
 - .3 submit copies of calculations signed by same engineer who signs layout drawings, and a listing of design data used in preparing calculations, system layout and sizing;
 - .4 in addition to submitting shop drawings to regulatory authority as specified above, shop drawings must be approved by Owner's insurer prior to being submitted to Consultant for review.

1.2 Quality Assurance

- .1 Fire protection standpipe system work is to be in accordance with following Codes and Standards:
 - .1 NFPA 14, Standard for the Installation of Standpipes and Hose Systems;
 - .2 CSA B137.2, Polyvinylchloride (PVC) Injection-Moulded Gasketed Fittings for Pressure Applications;
 - .3 CSA B137.3, Rigid Polyvinylchloride (PVC) Pipe and Fittings for Pressure Applications;
 - .4 ASTM A53, Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc Coated, Welded and Seamless;
 - .5 ASTM A234, Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service;
 - .6 ASTM A536, Standard Specification for Ductile Castings;
 - .7 ANSI/ASME B16.4, Grey Iron Threaded Fittings (Classes 125 and 250);
 - .8 CAN/CSA B64.10, Backflow Preventers and Vacuum Breakers.

Fire Protection Standpipe System

- .2 Site personnel are to be licensed in jurisdiction of the work and under continuous supervision of a foreman who is an experienced fire protection system installer and a journeyman pipe fitter licensed in jurisdiction of the work.
- .3 Check and verify dimensions and conditions at site and ensure work can be performed as indicated. Coordinate work with trades at site and accept responsibility for and cost of making adjustments to piping and/or spacing to avoid interference with other building components.
- .4 Verify working condition of existing standpipe system equipment which has direct interface with project work and is to remain. Replace with new equipment where necessary.
- .5 System components must be ULC listed and labelled and FM approved.
- .6 All grooved couplings, and fittings, valves and specialties are to be products of a single manufacturer. Grooving tools are to be of same manufacturer as grooved components.
- .7 All castings used for coupling housings, fittings, valve bodies, etc., are to be date stamped for quality assurance and traceability.

1.3 Design Requirements

- .1 Fire protection standpipe work is to be designed in accordance with NFPA 14 and Provincial Standards, and, where required, local building and fire department requirements and standards of Owner's Insurer. If water supply flow and pressure test data is not available, conduct Municipal main water flow and pressure tests at nearest fire hydrant to obtain criteria to be used in system design. Include hydrant location and flow and pressure test data with system design calculations.
- .2 Include for a qualified mechanical professional engineer registered and licensed in the jurisdiction of the work to design the fire protection standpipe work. Refer to Section entitled Mechanical Work General Instructions for requirements regarding Contractor retained engineers.

PART 2 - PRODUCTS

2.1 Pipe, Fittings and Joints

- .1 Pipe, fittings and joints are to be as follows, with exceptions as specified in Part 3 of this Section:
 - .1 Schedule 40 Steel – Grooved Coupling Joints
 - .1 Schedule 40 mild black carbon steel, ASTM A53, Grade B, complete with fittings and couplings equal to Victaulic "FireLock" fittings and Victaulic Style 009N, 107H, and 107N QuickVic and 005 rigid coupling joints. Strap-on fittings such as Victaulic "Snap-Let" strap type fittings are not acceptable.
 - .2 Victaulic Standard Mechanical Couplings: Manufactured in two segments of cast ductile iron, conforming to ASTM A-536, Grade 65-45-12. Gaskets are to be pressure-responsive synthetic rubber, grade to suit intended service, conforming to ASTM D-2000. Mechanical Coupling bolts are to be zinc plated (ASTM B-633) heat treated carbon steel track head conforming to ASTM A-449 and ASTM A-183. Couplings are to comply with ASTM F1476, Standard Specification for Performance of Gasketed Mechanical Couplings for Use in Piping Applications.

Fire Protection Standpipe System

- .1 Rigid Type: Coupling housings with offsetting, angle-pattern bolt pads are to be used to provide system rigidity and support and hanging in accordance NFPA-13. Couplings are to be fully installed at visual pad-to-pad offset contact. Couplings that require exact gapping of bolt pads at specific torque ratings are not permitted.
- .2 Flexible Type: Use in locations where vibration attenuation and stress relief are required. Victaulic Style 177 (Quick-Vic™), flexible coupling.
- .2 Schedule 40 Steel – Screwed and Welded Joints
 - .1 Schedule 40 mild black carbon steel, ASTM A53, Grade B. Screwed piping is to be complete with Class 125 cast iron screwed fittings to ANSI/ASME B16.4. Welded piping is to be complete with factory made seamless carbon steel butt welding fittings to ASTM A234, Grade WPB, long sweep pattern wherever possible.

2.2 Service Main Double Check Valve Assembly

- .1 Minimum 1205 kPa (175 psi) rated dual check valve backflow preventer assembly to CAN/CSA B64, complete with tight-closing resilient seated shut-off valves, test cocks and strainer.
- .2 Acceptable manufacturers are:
 - .1 Watts Industries Canada;
 - .2 Zurn/Wilkins;
 - .3 Apollo Valves (Conbraco Industries).

2.3 Shut-Off Valves

- .1 Minimum 2070 kPa (300 psi) rated full port brass or bronze body screwed ball valves and lug body or grooved end type butterfly valves.
 - .1 Butterfly valves are to include a pressure responsive seat, and stem is to be offset from disc centerline to provide complete 360° circumferential seating.
 - .2 Standard of Acceptance: Victaulic Style 705.
 - .3 Supervised closed applications standard of acceptance Victaulic Series 707C supervised closed butterfly valve.
- .2 OS&Y Gate Valves: 1725 kPa (250 psi), grooved ends, ductile iron body, yoke, and handwheel conforming to ASTM A-536, EPDM coated ASTM A-126-B cast iron disc, ASTM B16 brass rising stem, flanged and epoxy coated ductile iron bonnet, EPDM O-ring stem seals and body gasket. Victaulic Series 771H (Grooved ends) and Series 771F (Grooved x Flanged).

2.4 Check Valves

- .1 Minimum 1725 kPa (250 psi) resilient seat check valves suitable for vertical or horizontal installations. Standard of Acceptance: Victaulic Series 717.
- .2 Check valves associated with Fire Department connection(s) and fire pump test connection are to be tapped for site installation of a 20 mm (¾") dia. ball drip.

Fire Protection Standpipe System

2.5 Shut-Off Valve Supervisory Switches

- .1 Tamper-proof supervisory switches, each arranged to activate a fire alarm system trouble alarm condition if the valve is closed or tampered with, each suitable in all respects for the application, and each complete with required mounting and connection hardware.
- .2 Actuator housings are to be weatherproof.

2.6 Fire Protection Main "Loss Of Pressure" Alarm Sensor

- .1 Piping mounted adjustable pressure sensor designed to actuate an alarm upon sensing a loss of pressure in fire protection main. Switch is to be low voltage or line voltage as required.

2.7 Dry Pipe Zone Valve

- .1 Equal to a Victaulic Series 768-NXT:
 - .1 Series 746-LPA accelerator quick opening device;
 - .2 Series 757 regulated air maintenance trim assembly;
 - .3 required air pressure: (90 kPa) 13 psig;
 - .4 externally resettable valve;
 - .5 Series 757 regulated air maintenance trim assembly.
- .2 Provide valve complete with internal components that are replaceable without removing valve from installed position.
- .3 Systems requiring a quick opening device are to use a regulated, tank mounted air supply.

2.8 Dry Pipe Zone Air Compressor

- .1 Equal to a Victaulic 7C7, CSA certified, oil-less, piston type direct driven compressor with a motor conforming to requirements specified in Section entitled Basic Mechanical Materials and Methods, and a mounting bracket.
- .2 Equal to General Air Products OLT Series package type, oil-free, piston type, tank mounted air compressor set complete with a horizontal ASME rated and stamped steel tank with support feet, pressure gauge with gauge cock, tank drain, flexible compressor to tank and tank to piping flexible connections supplied loose for field installation, and a motor conforming to requirements specified in Section entitled Basic Mechanical Materials and Methods.
- .3 Compressor set capacity and performance must suit final dry pipe system design and reviewed piping shop drawings. If a larger compressor set than that specified is required, provide larger set at no additional cost, and include any additional costs for a larger size motor starter and associated wiring.

2.9 Fire Hose Cabinets

- .1 National Fire Equipment Ltd. fire hose cabinet assemblies as indicated on drawings and as specified below.
- .2 Cabinet construction, unless otherwise specified, as follows:
 - .1 cold rolled steel with a baked enamel finish;

Fire Protection Standpipe System

- .2 #18 gauge with universal knockouts for tubs;
- .3 #14 gauge for doors and trim;
- .4 all metal edges ground and rounded;
- .5 doors complete with:
 - .1 hollow channel reinforcement;
 - .2 full length semi-concealed piano hinge with paint stop feature and designed to permit 180° door opening;
 - .3 full removable panel of "Duo-Lite" 6 mm (¼") thick clear safety glass with adhesive centre;
 - .4 Model SMSS flush stainless steel door latch.
- .3 Cabinet mounting and sizes as follows:
 - .1 recessed cabinets – Model "Knight 200-2", 760 mm x 760 mm x 200 mm (30" x 30" x 8") with 12 mm (½") turnback frame and 50 mm (2") frame adjustment;
- .4 Fire Department Hose Valve – Model A56, 65 mm (2-½"), forged brass, satin finish, Fire Department angle hose valve with cap and chain.
- .5 Hose Rack, Hose and Nozzle – Model S-4 stationary hose rack with independently swivelling pins, a Model S-5 automatic water stop, and 30 m (100') of "Poly-Flex" 100% synthetic 40 mm (1-½") diameter hose with Model A70BO forged brass couplings and a Model A7B forged brass nozzle with rubber bumper and adjustment for fog, straight stream and shutoff.
- .6 Spanner Wrench – Model C-21 "Trinal" spanner wrench.
- .7 Fire Extinguisher – Stored pressure, multi-purpose, 2.26 kg (5 lb), 3A10B:C rated dry chemical extinguisher.
- .8 Cabinets of stainless steel construction are to be as specified above but constructed of Type 304 stainless steel with a #4 satin finish applied to door and frame after fabrication and removal of weld spots.
- .9 Acceptable manufacturers are:
 - .1 National Fire Equipment Ltd.;
 - .2 Wilson & Cousins;
 - .3 Potter-Roemer Inc.

2.10 Valve Cabinets and Combination Cabinets

- .1 Combination Fire Hose / Sprinkler Zone Control Sprinkler Cabinet – National Fire Equipment Ltd. Model CTHV-300 flush wall mounting cabinet assemblies, horizontal or vertical as indicated, each assembly complete with a common 50 mm (2") adjustable frame, #18 gauge steel tubs with a black baked enamel finish, concealed hinges and door latches, and following:
 - .1 fire hose cabinet – 760 mm x 760 mm x 200 mm (30" x 30" x 8") deep, as specified in this Section and equipped with stainless steel trim and a full glass door;

Fire Protection Standpipe System

- .2 sprinkler valve cabinet – 760 mm x 760 mm (30" x 30") with a depth to suit valves and piping contained, and a full stainless steel door.
- .2 Fire Hose Valve Cabinets – National Fire Equipment Ltd. Model C-975 hose valve cabinet assemblies with Fire Department hose valves and a spanner wrench, 355 mm x 355 mm x 200 mm (14" x 14" x 8") deep, each constructed of cold rolled steel with a baked enamel finish, #18 gauge for tubs, #14 gauge for doors and trim, with metal edges ground and rounded. Cabinets are to be complete with:
 - .1 doors equipped with full length semi-concealed piano hinge with paint stop feature and designed to permit 180° door opening, a removable panel of "Duo-Lite" 6 mm (¼") thick clear safety glass with adhesive centre, and a Model SMSS stainless steel door latch;
 - .2 Model A56 65 mm (2-½"), forged brass, satin finish, Fire Department angle hose valves with caps and chains, each chrome plated and polished;
 - .3 Model C-21 "Trinal" spanner wrench.

2.11 Fire Department Hose Valves

- .1 National Fire Equipment Ltd. Model A56, 65 mm (2-½") forged brass angle hose valves, each complete with a cap and chain.
- .2 Acceptable manufacturers are:
 - .1 National Fire Equipment Ltd.;
 - .2 Wilson and Cousins;
 - .3 Potter-Roemer Inc.

PART 3 - EXECUTION

3.1 Demolition

- .1 Refer to demolition requirements specified in Section entitled Demolition and Revision Work.

3.2 Piping Installation Requirements

- .1 Provide required standpipe system piping. Unless otherwise specified, piping is to be as follows:
 - .1 for underground pipe inside or outside the building, Class 200, DR14 rigid PVC, braced and secured at bends and tees with concrete blocks in accordance with Municipal standards and details;
 - .2 for piping inside building and above ground, Schedule 40 grooved end black steel with Victaulic or equal fittings and coupling joints, or, for piping to and including 50 mm (2") diameter, screwed fittings and joints or piping 65 mm (2-½") diameter and larger, welding fittings and welded joints.
- .2 Perform piping work in accordance with requirements of NFPA 14, governing regulations, and "reviewed" shop drawings.
- .3 Exceptions to piping requirements specified above are as follows:

Fire Protection Standpipe System

- .1 dry pipe zone steel piping, fittings, unions, couplings and flanges are to be galvanized;
- .2 steel piping, fittings, unions, couplings and flanges for work exposed to weather either inside or outside the building (including parking garages), are to be galvanized;
- .3 ferrous pipe hangers, supports, and similar hardware used for galvanized steel piping are to be galvanized.
- .4 Pipe sizes, pipe routing, and layout of work shown on drawings are to assist during the tendering period. Do not reduce size of standpipe main or re-route the main unless approved by Consultant.
- .5 Install grooved joints in accordance with manufacturer's latest installation instructions. Grooved ends are to be clean and free from indentations, projections and roll marks. Gaskets are to be moulded and produced by coupling manufacturer, and verified as suitable for intended service. Have factory-trained representative from mechanical joint manufacturer provide on-site training in proper use of grooving tools and installation of grooved piping products. Have factory-trained representative periodically review product installation and ensure best practices are being followed. Remove and replace any improperly installed products.
- .6 Clean pipe, fittings, couplings, flanges, and similar components after erection is complete. Wire brush clean any ferrous pipe, fitting, coupling, flange, hanger, support and similar component which exhibit rust and carefully coat with suitably coloured primer.
- .7 Slope horizontal piping so it may be completely drained. Provide capped drain points.
- .8 Provide a pressure gauge at the highest outlet in each standpipe riser. Locate gauges so they can be read easily. Where possible, locate gauges in fire hose cabinets. See Section entitled Basic Mechanical Materials and Methods for pressure gauge requirements.

3.3 Installation of Fire Hose Cabinets

- .1 Provide fire hose cabinets.
- .2 Confirm exact cabinet locations prior to roughing-in.

END OF SECTION

Fire Protection Sprinkler System

PART 1 - GENERAL

1.1 Submittals

- .1 Submit shop drawings/product data sheets to regulatory authority for review and approval prior to submitting to Consultant. Conform to following requirements:
 - .1 submit shop drawings/product data sheets for products specified in this Section except pipe and fittings;
 - .2 submit complete CAD layout drawings indicating source of water supply with test flow and pressure, "head-end" equipment piping schematic, pipe routing and sizing, and zones, all signed and sealed by a qualified professional mechanical engineer registered in jurisdiction of the work as specified below;
 - .3 submit copies of calculations, including hydraulic calculations, stamped and signed by same engineer who signs layout drawings, and a listing of design data used in preparing calculations, system layout and sizing, including occupancy-hazard design requirements;
 - .4 in addition to submitting shop drawings to regulatory authority as specified above, shop drawings must be approved by Owner's insurer prior to being submitted to Consultant for review.
- .2 Submit a complete sprinkler system test certificate as specified in Part 3 of this Section.
- .3 Sprinklers are to be identified on drawings and product submittals, and be specifically identified by manufacturer's listed model or series designation. Trade names and other abbreviated listings are unacceptable.

1.2 Quality Assurance

- .1 Fire protection sprinkler system work is to be in accordance with following codes and standards:
 - .1 NFPA 13, Standard for the Installation of Sprinkler Systems;
 - .2 CSA B137.2, Polyvinylchloride (PVC) Injection-Moulded Gasketed Fittings for Pressure Applications;
 - .3 CSA B137.3, Rigid Polyvinylchloride (PVC) Pipe for Pressure Applications;
 - .4 ASTM A53, Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc Coated, Welded and Seamless;
 - .5 ASTM A135, Standard Specification for Electric-Resistance-Welded Steel Pipe;
 - .6 ASTM A234, Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service;
 - .7 ASTM A536, Standard Specification for Ductile Castings;
 - .8 ASTM A795, Standard Specification for Black and Hot-Dipped Zinc Coated (Galvanized) Welded and Seamless Steel Pipe for Fire Protection Use;
 - .9 ANSI/ASME B16.4, Grey Iron Threaded Fittings (Classes 125 and 250);
 - .10 CAN/CSA B64.10, Backflow Preventers and Vacuum Breakers.

Fire Protection Sprinkler System

- .2 Verify working condition of existing sprinkler system equipment which has direct interface with project work and is to remain. Replace with new equipment where necessary.
- .3 System components must be ULC listed and labelled.
- .4 Grooved couplings, and fittings, valves and specialties are to be products of a single manufacturer. Grooving tools are to be of same manufacturer as grooved components.
- .5 Castings used for coupling housings, fittings, valve bodies, etc., are to be date stamped for quality assurance and traceability.

1.3 Design Requirements

- .1 Design fire protection sprinkler work in accordance with NFPA 13 and local Provincial Standards, and, where required, local building and fire department requirements and standards of Owner's Insurer. If water supply flow and pressure test data is not available, conduct Municipal main water flow and pressure tests at nearest fire hydrant to obtain criteria to be used in system design. Include hydrant location and flow and pressure test data with system design calculations.
- .2 Include for a qualified mechanical professional engineer registered and licensed in the jurisdiction of the work to design the fire protection sprinkler work. Refer to Section entitled Mechanical Work General Instructions for requirements regarding Contractor retained engineers.
- .3 Sprinkler/System Occupancy – Hazard Design requirements: In accordance with NFPA 13 occupancy-hazard density requirements, unless otherwise specified.

PART 2 - PRODUCTS

2.1 Pipe, Fittings and Joints

- .1 Pipe, fittings and joints are to be as follows, with exceptions as specified in Part 3 of this Section:
 - .1 Schedule 40 Steel – Grooved Coupling Joints
 - .1 Schedule 40 mild black carbon steel, ASTM A53, Grade B, complete with grooved ends and mechanical fittings and couplings, Victaulic "FireLock" fittings and Victaulic Style 009N, 107H, and 107N QuickVic and 005 or approved equal, rigid coupling joints. Strap type outlet fittings such as Victaulic "Snap-Let" are not acceptable.
 - .2 Schedule 40 Steel – Screwed and Welded Joints
 - .1 Schedule 40 mild black carbon steel, ASTM A53, Grade B. Screwed piping complete with Class 125 cast iron screwed fittings to ANSI/ASME B16.4. Welded piping complete with factory made seamless carbon steel butt welding fittings to ASTM A234, Grade WPB, long sweep pattern wherever possible.
 - .3 Schedule 10 Steel – Grooved Coupling Joints
 - .1 Schedule 10 mild black carbon steel, ASTM A53, Grade B, complete with grooved ends and fittings and couplings, Victaulic "FireLock" fittings and Victaulic Style 009N, 107H, and 107N QuickVic and 005, or approved equal, rigid coupling joints.
 - .4 Schedule 10 Steel – Screwed Joints

Fire Protection Sprinkler System

- .1 Schedule 10 mild black carbon steel, ASTM A53, Grade B, complete with mill or site threaded ends, Class 125 cast iron screwed fittings to ANSI/ASME B16.4, and screwed joints.
- .5 "Lightwall" Steel – Grooved Coupling Joints
 - .1 Commercial quality. "Lightwall" rolled mild carbon steel pipe to ASTM A135, Grade A, complete with a galvanized exterior, grooved ends, and fittings and couplings, Victaulic "Fire Lock" grooved fittings and Victaulic Style 009N QuickVic or 005 rigid coupling joints or approved equal.
- .6 "Lightwall" Steel – Screwed Joints
 - .1 Commercial quality, "Lightwall" rolled mild carbon steel pipe to ASTM A135, Grade A, ULC listed, mill or site threaded, complete with galvanized exterior, Class 125 cast iron screwed fittings to ANSI/ASME B16.4, and screwed joints.
- .7 CPVC Pipe
 - .1 IPEX BlazeMaster or approved equal, solvent weld, orange, SDR 13.5 pipe and Schedule 80 fittings, ULC listed for use in wet pipe automatic sprinkler systems, with a flame spread rating less than 25 and a smoke developed rating less than 50 when tested in accordance with CAN/ULC S102.2, and in accordance with NFPA 13 requirements.
- .8 Standard Mechanical Couplings: Equal to Victaulic
 - .1 Manufactured in two segments of cast ductile iron, conforming to ASTM A-536, Grade 65-45-12. Gaskets are to be pressure-responsive synthetic rubber, grade to suit intended service, conforming to ASTM D-2000. Mechanical coupling bolts are to be zinc plated (ASTM B-633) heat treated carbon steel track head conforming to ASTM A-449 and ASTM A-183. Couplings are to comply with ASTM F1476 - Standard Specification for Performance of Gasketed Mechanical Couplings for Use in Piping Applications.
 - .2 Rigid Type: Coupling housings with offsetting, angle-pattern bolt pads are to be used to provide system rigidity and support and hanging in accordance NFPA-13. Couplings are to be fully installed at visual pad-to-pad offset contact. Couplings that require exact gapping of bolt pads at specific torque ratings are not permitted.
 - .3 Flexible Type: Use in locations where vibration attenuation and stress relief are required; Victaulic Style 177 (Quick-Vic™) or approved equal, flexible coupling.
- .2 Victaulic 7C7 or approved equal, CSA certified, oil-less, piston type direct driven compressor with a motor conforming to requirements specified in Section entitled Basic Mechanical Materials and Methods, and a mounting bracket.
- .3 General Air Products OLT Series or approved equal, package type, oil-free, piston type, tank mounted air compressor set complete with horizontal, ASME rated and stamped steel tank with support feet, pressure gauge with gauge cock, tank drain, flexible compressor to tank and tank to piping flexible connections supplied loose for field installation, and a motor conforming to requirements specified in Section entitled Basic Mechanical Materials and Methods.
- .4 Compressor set capacity and performance must suit final dry pipe system design and reviewed piping and sprinkler head layout shop drawings. If a larger compressor set than

Fire Protection Sprinkler System

that specified is required, provide larger set at no additional cost, and include any additional costs for a larger size motor starter and associated wiring.

2.2 Preaction Valve and Accessories

- .1 Victaulic Series 745 FirePac or approved equal, pre-assembled Dry/Preaction/ Deluge fire protection valve mounted completely within a steel cabinet for sizes 40 mm (1-½") through 203 mm (8"). Unit is to be ULC listed with all materials and wiring conforming to NFPA requirements.
- .2 Cabinet is to be coated with red ASA-61 electrostatically applied polyester powder coating. Cabinet is to have field removable access panels on three sides to allow for ease of valve maintenance, servicing, and installation. Unit is to be provided with Series 728 ball valve or Series 705 butterfly shutoff valve with pre-wired supervisory switches, sprinkler system fire protection valve, alarm line pressure switches, air supervisory pressure switches, alarm pressure switch and pressure gauges for proper operation and is to be pre-wired to Model RP-2001 control panel. External electrical connections are to be able to be connected through a factory provided conduit connection to an enclosure inside of cabinet. Water inlet, system supply, and drain connections are to be grooved for ease of installation.
- .3 Victaulic FireLock NXT Series or approved equal, valve is to be low differential, latched clapper design with a black enamel coated ductile iron body conforming to ASTM A536, aluminum bronze clapper, stainless steel spring and shaft, EPDM diaphragm and seal, brass seat with nitrile seat o-rings. Valve internal parts are to be replaceable without removing valve from installed position and are to be externally resettable. 2070 kPa (300 psi) pressure rating in sizes 40 mm (1-½") through 203 mm (8") and are to be grooved ends for vertical installation only.
- .4 Trim configurations:
 - .1 Dry Valve: Pneumatic operation.
 - .2 Preaction Valve:
 - .1 Non-interlock; Pneumatic.
 - .2 Single interlock; Electric.
 - .3 Double interlock; Pneumatic and Electric.
 - .3 Deluge Valve:
 - .1 Electric release.
 - .2 Wet pilot.
 - .3 Dry pilot.
- .5 Electric Release Panel: Notifier Model RP-2001 or approved equal, compact single enclosure unit containing power supply, two 12 Amp-hr batteries and availability to have factory installed accessory features to suit specific applications.
- .6 Preassembled cabinet is to have pipe penetrations sealed to meet NEMA 4 protection of equipment inside of enclosure with respect to ingress of water, whether rain, sleet, snow, splashing water or hose directed water.
- .7 Preassembled cabinet is to have nitrogen fill options as well as factory installed low nitrogen pressure alarm to augment low air alarms as needed in certain trim applications.

Fire Protection Sprinkler System

- .8 Acceptable manufacturers are:
 - .1 Victaulic Co.;
 - .2 FireFlex System Inc.;
 - .3 Reliable Automatic Sprinkler Co. Inc.

2.3 Sprinkler Heads

- .1 Sprinkler heads, unless otherwise specified, are to be as scheduled in Part 3 of this Section.
- .2 Sprinkler body is to be die-cast, with hex-shaped wrench boss integrally cast into sprinkler body to reduce risk of damage during installation. Wrenches are to be provided by sprinkler manufacturer that directly engages wrench boss.
- .3 For locations where corrosive resistant coatings are required, body is to be coated with ULC listed and FM approved anti-corrosion VC-250 coating (silver colouring).
- .4 Sprinkler heads for healthcare facilities are to be quick response type.
- .5 Recessed sprinkler heads in finished areas are to be chrome plated unless otherwise specified. Concealed sprinkler head ceiling plates are to match ceiling colour.
- .6 Where exposed pendent heads occur in areas with suspended ceilings, they are to be complete with chrome plated escutcheon plates. Similarly, sidewall heads with concealed piping are to be complete with chrome plated escutcheon plates.
- .7 Sprinkler heads which are exposed in areas where they may be subject to damage are to be complete with wire guards, chrome plated where in finished areas.
- .8 Escutcheons and guards are to be listed, supplied, and approved for use with sprinkler by sprinkler manufacturer.
- .9 Sprinkler heads located in areas or over equipment where high ambient temperature is present are to be, unless otherwise specified, 93°C (200°F) heads. Other heads, unless otherwise specified or required, are to be 68°C (155°F) rated.
- .10 Acceptable manufacturers are:
 - .1 Victaulic Co.;
 - .2 Tyco Fire Suppression & Building Products;
 - .3 The Viking Corporation;
 - .4 The Reliable Automatic Sprinkler Co.

2.4 Spare Sprinkler Head Cabinet

- .1 Surface wall mounting, red enamelled steel, identified cabinet with hinged door, shelves with holes for mounting sprinkler heads, a wrench or wrenches suitable for each type of sprinkler head, and full complement of spare sprinkler heads.
- .2 Cabinet is to be sized to accommodate a minimum of 4 spare heads for each type of head used on project, however, each cabinet is to be full of spare heads.

PART 3 - EXECUTION

3.1 Monitoring of Systems

Fire Protection Sprinkler System

- .1 Daily monitor and supervise existing sprinkler system serving renovated areas to ensure that each respective system is left in proper operating condition at end of each working day. Include for but not be limited to performing following:
 - .1 Under presence of Owner's representative, check each morning and evening (start and end of work) of each day, sprinkler system to ensure that it is in proper working condition;
 - .2 If portions of sprinkler system is not in proper working order, provide temporary provisions subject to approval of local fire authority or local governing authority, to ensure that proper sprinkler coverage is provided and/or provide supervisory personnel to monitor areas where sprinkler system is not operational;
 - .3 Document and sign off with Owner's representative signing off also, each respective daily check condition;
 - .4 Ensure that work to sprinkler system does not affect portion of system serving areas outside of renovation areas.

3.2 Demolition

- .1 Refer to demolition requirements specified in Section entitled Demolition and Revision Work.

3.3 Piping Installation Requirements

- .1 Provide required sprinkler system piping.
- .2 Perform piping work in accordance with requirements of NFPA 13, governing regulations, and "Reviewed" shop drawings.
- .3 Piping, unless otherwise specified, is as follows:
 - .1 for underground piping inside or outside building – Class 200, DR14 rigid PVC, braced and secured at bends and tees with concrete blocks in accordance with Municipal standards and details;
 - .2 for piping inside building and above ground except as noted below – Schedule 40 grooved end black steel with Victaulic or equal fittings and coupling joints, or, for piping to and including 50 mm (2") diameter, screwed fittings and joints, or, for piping 65 mm (2-½") diameter and larger, welding fittings and welded joints;
 - .3 for wet system piping inside building and above ground – at your option, CPVC sprinkler pipe and fittings;
 - .4 for piping downstream of "head end" alarm valve(s) and equipment – Schedule 10 or "Lightwall" black steel pipe with Victaulic or equal fittings and coupling joints or screwed fittings and joints;
- .4 Exceptions to piping requirements specified above are as follows:
 - .1 dry pipe zone steel piping, fittings, unions, couplings and flanges are to be galvanized;
 - .2 wet zone steel piping, fittings, unions, couplings and flanges for sprinkler work exposed to weather either inside or outside building (including parking garages), are to be galvanized;
 - .3 PVC piping is not to be used above grade;

Fire Protection Sprinkler System

- .4 ferrous pipe hangers, supports, and similar hardware used for galvanized steel piping are to be electro-galvanized.
- .5 Pipe sizes, pipe routing, sprinkler head quantities and locations, and layout of work shown on drawings are to assist during Bid period. Ensure adequate head coverage, head quantities and pipe sizing as specified in Part 1 of this Section. Do not reduce size of sprinkler main or re-route main unless reviewed with Consultant and accepted by Owner.
- .6 Install grooved joints in accordance with manufacturer's latest installation instructions. Grooved ends are to be clean and free from indentations, projections and roll marks. Gaskets are to be moulded and produced by coupling manufacturer, and verified as suitable for intended service. Have factory-trained representative from mechanical joint manufacturer provide on-site training in proper use of grooving tools and installation of grooved piping products. Have factory-trained representative periodically review product installation and ensure best practices are being followed. Remove and replace any improperly installed products.
- .7 Clean pipe, fittings, couplings, flanges and similar components after erection is complete. Wire brush clean any ferrous pipe, fitting, coupling, flange, hanger, support and similar component which exhibit rust and carefully coat with suitably coloured primer.

3.4 Installation of Dry Zone Air Compressor

- .1 Provide an air compressor with air maintenance device and pressure control for dry pipe zone and dry pipe valve. Secure compressor to a piping main by means of a mounting bracket supplied with compressor. Adjust to suit site conditions.
- .2 Provide an air compressor set with receiver and secure in place on rubber-steel-rubber vibration isolation pads on a concrete housekeeping pad.
- .3 Install flexible piping connections supplied loose with set.
- .4 Extend valved drain piping from receiver to a floor drain.
- .5 Connect receiver and control panel pressure switch with copper tubing.
- .6 When installation is complete, check and test air compressor set, including automatic operation, and adjust as required.

3.5 Installation of Preaction Sprinkler System

- .1 Provide a preaction sprinkler system.
- .2 Install preaction deluge valve cabinet assembly with control panel and air compressor as indicated but confirm exact location prior to roughing-in.
- .3 Provide required water supply, compressed air, sprinkler, and drain piping. Terminate drain piping over a funnel floor drain.
- .4 Provide detection devices and install in accordance with manufacturer's instructions. Connect to control panel with wiring in conduit.
- .5 Supply detection devices and hand to electrical trade on site for installation.
- .6 Include for 4 hours of on-site operation demonstration and training session. Training is to be full review of components including but not limited to full operation and maintenance demonstration, with abnormal events.

3.6 Installation of Sprinkler Heads

- .1 Provide required sprinkler heads in accordance with following schedule:

[illegible]

Fire Protection Sprinkler System

APPLICATION	SPRINKLER HEAD TYPE
At non-rated windows in rated walls	Tyco Model WS horizontal and pendent vertical sidewall

- .2 Sprinkler head manufacturers indicated on schedule are for type indication purposes. Acceptable manufacturers are listed in Part 2 of this Section.
- .3 Provide quick response type sprinkler heads for healthcare facilities.
- .4 Coordinate sprinkler head locations with drawings, including architectural reflected ceiling plan drawings, and, where applicable, electrical drawings. Coordinate sprinkler head locations in areas with suspended ceilings with location of lighting, grilles, diffusers, and similar items recessed in or surface mounted on ceiling as per reflected ceiling plans. In areas with lay-in tile, centre sprinkler head both ways in lay-in tile wherever possible. Confirm locations prior to roughing-in.
- .5 Maintain maximum headroom in areas with no ceilings.
- .6 Provide guards for heads where they are subject to damage.
- .7 Provide high temperature heads in equipment rooms and similar areas over heat producing or generating equipment.

3.7 Installation of Spare Sprinkler Head Cabinet

- .1 Supply full complement (to fill cabinet) of spare sprinkler heads of types used (minimum 4 of each type) and place in a wall mounting storage cabinet located adjacent to sprinkler system "head end" equipment where later directed.

3.8

END OF SECTION

Fire Extinguishers

PART 1 - GENERAL

1.1 Submittals

- .1 Submit product data sheets for all products specified in this Section.

1.2 Quality Assurance

- .1 Fire extinguishers are to be in accordance with following Codes and Standards:
 - .1 National Fire Code of Canada;
 - .2 NFPA 10, Standard for Portable Fire Extinguishers;
 - .3 CAN/ULC S508, Standard for the Rating and Testing of Fire Extinguishers.

PART 2 - PRODUCTS

2.1 General

- .1 Fire extinguishers are to be pressurized (stored pressure) rechargeable type, in accordance with NFPA 10, and UL and/or ULC listed and labelled for the class of fires and hazard locations for which they are specified.
- .2 Each extinguisher is to be complete with:
 - .1 manufacturer's identification label indicating extinguisher model number, rating, and operating instructions;
 - .2 anodized aluminum or chrome plated forged brass valve with positive squeeze grip on-off operation and a pull-pin safety lock;
 - .3 discharge hose with nozzle or horn and hose securing clip;
 - .4 for wall mounting extinguishers, a wall mounting bracket.
- .3 Fire extinguishers in fire hose cabinets will be supplied with the cabinet and are specified in Section entitled Fire Protection Standpipe System.

2.2 10B:C. Rated Carbon Dioxide Extinguishers

- .1 10B:C carbon dioxide extinguishers are to be 175 mm (6-1/2") dia., 6.8 kg (15 lb.), each complete with a steel cylinder with a safety red baked enamel finish.

2.3 3A10B:C Rated Dry Chemical Extinguishers

- .1 Multi-purpose 3A10B:C dry chemical extinguishers are to be 100 mm (4") dia., 2.27 kg (5 lb.), each complete with a steel cylinder with a safety red baked enamel finish and a waterproof stainless steel pressure gauge.

2.4 Clean Agent Fire Extinguishers

- .1 Ansul Inc. model CleanGuard FE13 clean agent extinguisher, 6 kg (13.25 lb.), ULC listed and labelled to 2-A:10-B:C, suitable for fires involving live electrical equipment and will not damage the equipment, each complete with required wall mounting brackets and securing hardware.
- .2 Acceptable manufacturers are:

Fire Extinguishers

- .1 Ansul Inc.;
- .2 Pyro Chem.

2.5 Fire Extinguisher Cabinets

- .1 Surface Mounted: Rectangular break-glass type enclosures sized to suit the extinguishers to be housed, constructed of #18 gauge corrosion resistant steel with a baked white enamel finish, front glass panel, break-glass mechanism, and keyed alike cylinder lock.
- .2 Recessed: Rectangular cabinets sized to suit the extinguishers to be housed, with a #18 gauge corrosion resistant white enamelled steel tub, #14 gauge cleaned and prime coat painted steel door and adjustable trim assembly with rounded corners, semi-concealed piano hinge, safety glass panel, and flush stainless steel door latch.

PART 3 - EXECUTION

3.1 Installation of Fire Extinguishers

- .1 Provide fire extinguishers of type(s) in accordance with requirements of NFPA 10.
- .2 Unless otherwise shown or specified, wall mount extinguishers using wall brackets supplied with extinguishers.
- .3 Do not install extinguishers until after wall finishing work is complete.
- .4 Be responsible for maintaining fire extinguishers until Substantial Completion of the Work.
- .5 If extinguishers are indicated adjacent to a door, locate extinguishers at the strike side of the door.

3.2 Installation of Fire Extinguisher Cabinets

- .1 Provide wall cabinets for fire extinguishers where required.
- .2 Unless otherwise shown or specified, locate cabinets so centerline is approximately 1.2 m (4') above finished floor.
- .3 Confirm exact locations prior to installation.

END OF SECTION

PART 1 - GENERAL

1.1 Submittals

- .1 Submit shop drawings and product data sheets for products specified in Part 2 of this Section except for pipe, fittings, and chlorine.

1.2 Quality Assurance

- .1 Domestic water piping and valves are in accordance with following codes, regulations and standards (as applicable):
 - .1 applicable local codes and regulations;
 - .2 ASTM F1960, Standard Specification for Cold Expansion Fittings with PEX Reinforcing Rings for Use with Cross-linked Polyethylene (PEX) Tubing;
 - .3 CAN/CSA B125.1, Plumbing Supply Fittings;
 - .4 CAN/CSA B125.3, Plumbing Fittings;
 - .5 CAN/CSA B137 Series, Thermoplastic Pressure Piping Compendium;
 - .6 CAN/ULC S102.2, Standard Method of Test for Surface Burning Characteristics of Flooring, Floor Coverings, and Miscellaneous Materials and Assemblies;
 - .7 CAN/ULC S101, Fire Endurance Tests of Building Construction and Materials;
 - .8 NSF/ANSI 14, Plastics Piping System Components and Related Materials;
 - .9 NSF/ANSI 61, Drinking Water System Components – Health Effects;
 - .10 NSF/ANSI 372, Drinking Water System Components – Lead Content.

PART 2 - PRODUCTS

2.1 Pipe, Fittings and Joints

- .1 Stainless Steel
- .2 Hard Copper - Solder Joint
 - .1 Type "L" hard drawn seamless copper to ASTM B88, complete with copper solder type fittings to ASME/ANSI B16.18 and soldered joints using Canada Metal Co "SILVABRITE 100 lead-free solder for cold water pipe, and 95% tin/ 5% Antimony or "SILVABRITE 100" solder, for other services, or approved equal.
- .3 Copper Pressure Coupled Joint
 - .1 Type "L" hard drawn seamless copper to ASTM B88, with Viega "ProPress with Smart Connect feature", CSA approved, copper fittings with EDPM seals, and pressure type crimped joints made by use of manufacturer recommended tool.
- .4 Hard Copper – Grooved Joint
 - .1 Bolted grooved connection type system, suitable and approved for application intended, 50 mm to 200 mm (2" - 8") hard copper tubing, with Victaulic QuickVic Style 607 rigid coupling consisting of ductile iron cast housings, with Grade 'P' fluoroelastomer compound gasket of pressure-responsive design, with plated nuts and bolts to secure unit together.

Domestic Water Piping and Specialties

.5 Manufacturer Services

.1 Include manufacturers factory trained representative to:

- .1 For special piping applications such as PEX, grooved piping, crimping: Train installing Contractors on special installation practices and use of special tools for installations.
- .2 For grooved piping systems: Periodically visit job site to review installation, prepare inspection report, advise installing Contractor of deficiencies and re-examine, till corrections are made.

2.2 Shut-Off Valves

.1 Ball Valves

- .1 Class 600, 4140 kPa (600 psi) WOG rated, lead-free, full port ball type valves.
- .2 Forged brass body with solder ends, forged brass cap, blowout-proof stem, solid forged brass chrome plated ball, "Teflon" or "PTFE" seat. and removable lever handle.
- .3 Valves in insulated piping are to be complete with stem extensions.
- .4 Acceptable manufacturers are:
 - .1 Toyo Valve;
 - .2 Milwaukee Valve;
 - .3 Kitz Corporation;
 - .4 Apollo Valves;
 - .5 Watts Canada.

2.3 Check Valves

.1 Horizontal

- .1 Lead-free, Class 125, bronze, 1380 kPa (200 psi) WOG rated horizontal swing type check valves with solder ends.
- .2 Bronze body, cap and disc holder.
- .3 PTFE disc
- .4 Acceptable manufacturers are:
 - .1 Toyo Valve;
 - .2 Milwaukee Valve;
 - .3 Kitz Corporation;
 - .4 Apollo Valves.

.2 Vertical

- .1 Lead-free, 1725 kPa (250 psi) WOG rated, silent type, spring loaded, vertical lift check valve with soldering ends.
- .2 Cast bronze body, cap disc holder and phosphor bronze spring.

Domestic Water Piping and Specialties

.3 Acceptable manufacturers are:

- .1 Toyo Valve;
- .2 Milwaukee Valve;
- .3 Kitz Corporation;
- .4 Apollo Valves.

2.4 Drain Valves

- .1 Lead free, minimum 2070 kPa (300 psi) water rated, 20 mm ($\frac{3}{4}$ ") dia., straight pattern full port bronze ball valves.
- .2 Threaded outlet suitable for coupling connection of 20 mm ($\frac{3}{4}$ ") dia. garden hose, and a cap and chain.
- .3 Acceptable manufacturers are:
 - .1 Crane -Jenkins;
 - .2 Kitz Corporation;
 - .3 Apollo Valves;
 - .4 Milwaukee Valve;
 - .5 Dahl Bros.

2.5 Domestic Hot Water Piping Balancing Valves

- .1 Lead free, solder or NPT screwed end type as required, ball style, circuit balancing valves.
- .2 Designed to facilitate precise flow measurement, precision flow balancing, and positive shut-off.
- .3 Capped and valved drain connection, and capped ports for connection to differential pressure meter.
- .4 Acceptable manufacturers are:
 - .1 Bell & Gossett;
 - .2 Victaulic;
 - .3 Watts Canada.

2.6 Domestic Hot Water Thermostatic Mixing Valves

- .1 Lawler Manufacturing Co. 800 Series "High-Low Thermostatic Mixer", or approved equal, factory assembled rough bronze thermostatic mixing valve assembly complete with rotatable union end inlet piping with check stops and stainless steel strainer screens, union outlet piping with thermometer connection, sized as shown, and following:
 - .1 mixing valve with liquid motor, stainless steel piston and liner, tamper-resistant control adjustment, and 3-way protection against runaway temperatures, thermal shock, and scalding;

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- .2 dial type thermometer conforming to requirement specified in Section entitled Basic Mechanical Materials and Methods;
- .3 ball type outlet shut-off valve conforming to valve requirements specified and with outlet sized to suit intended applications;
- .4 surface wall mounting enamelled steel cabinet with hinged door, key lock, and permanent identification;
- .5 recessed wall mounting type 304 stainless steel cabinet with no. 4 finish, hinged door, key lock, and permanent identification.
- .2 Acceptable manufacturers are:
 - .1 Lawler Manufacturing Co. Inc.;
 - .2 Leonard Valve Co.;
 - .3 Symmons Industries Inc.

2.7 Chlorine

- .1 Sodium hypochlorite to AWWA B300.
 - .1 .

2.8 Non-Freeze Roof Hydrant

2.9 Floor Drain Trap Seal Primers

- .1 Primer Valve Type
 - .1 Precision Plumbing Products Inc. Model P2-500, or approved equal, trap primer valve, constructed of brass, adjustable to high or low water pressures and complete with "O" ring seals, 12 mm (½") threaded inlet and outlet connections, and, for priming two traps from the same primer, DU-2 dual outlet distribution unit.
- .2 Electronic Type
 - .1 Precision Plumbing Products #PT Series, or approved equal, surface wall mounting, CSA certified, 115 volt, 1-phase, 60 Hz., electronic, automatic trap priming manifolds, each sized to suit number of drain traps or interceptors serviced, and each complete with:
 - .1 galvanized steel cabinet with door;
 - .2 20 mm (¾") dia. NPT copper pipe inlet with shut-off valve and water hammer arrestor;
 - .3 solenoid valve, atmospheric vacuum breaker, and discharge manifold with 12 mm (½") dia. compression type copper tube connections on 40 mm (1-½") centres with quantity to suit number of items primed;
 - .4 control panel with circuit breaker, 5 ampere fuse, 24 hour timer, and manual override toggle switch.

2.10 Water Hammer Arrestors

- .1 Jay R. Smith 5000 Series, water hammer arrestors with following features:

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- .1 piston type, sealed, lead free, stainless steel construction;
- .2 or upright vertical installations;
- .3 factory pre-charged and sealed, pressurized compression chamber;
- .4 welded nesting-type expansion bellows surrounded by non-toxic mineral oil;
- .5 male treaded nipple connection.
- .2 Acceptable manufacturers are:
 - .1 Jay R. Smith;
 - .2 Precision Plumbing Products;
 - .3 Or approved equal.
- .3 Watts Canada, LM15M2/S Series, water hammer arrestors with features as follows:
 - .1 piston type, sealed, lead free, maintenance free;
 - .2 factory pre-charged and sealed, and pressurized;
 - .3 threaded or soldered connections to suit intended applications;
 - .4 suitable for either horizontal or vertical installation;
 - .5 hard drawn copper body;
 - .6 "O"-ring piston seals, air charge, and inlet opening equal to diameter of pipe in which arrestor is required.
- .4 Acceptable manufacturers are:
 - .1 Watts Canada;
 - .2 Zurn;
 - .3 Precision Plumbing Products;
 - .4 Mifab.

2.11 Piping Expansion Compensators and Guides

- .1 Pressurized type, selected to withstand system pressure and to suit calculated movement from minus 5°C (23°F) to maximum operating temperature plus 25% safety factor, complete with stainless steel bellows and shroud, copper tube sweat type female ends, anti-torque device, and proper and suitable alignment guides for both sides of each compensator.
- .2 Acceptable manufacturers and products are:
 - .1 Senior Flexonics Series HB;
 - .2 Hyspan Precision Products Series 8500.

2.12 Pipe Anchors

- .1 Welded structural black steel anchors of design, size, and type to securely anchor pipe at designated points. Each anchor withstands 150% axial thrust, and is designed and detailed by professional structural engineer registered and licensed in jurisdiction of Work. Submit anchor design and fabrication shop drawings, stamped by design Professional Engineer.

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2.13 Lavatory Supply Fitting Tempering Valves

- .1 Powers "HydroGuard" Series 490, model LM490, 12 mm (½") dia. or model LM491 20 mm (¾") dia., or approved equals, as required, each CSA B125 certified, forged brass, tamper-proof thermostatic mixing valves, adjustable for water supply between 29°C and 49°C (85°F and 120°F), sized to suit number of lavatories in grouping, and complete with stop and check valve and lockable handle.
- .2 Each mixing valve includes stainless steel flush wall mounting cabinet with vandal-proof hinged door.

2.14 Air Vents

- .1 ITT Hoffman Specialty No. 78, or approved equal, cast brass, 1035 kPa (150 psi) rated, 20 mm (¾"), straight water main vent valves, each tapped at top for 3.2 mm (1/8") safety drain connection.

PART 3 - EXECUTION

3.1 Demolition

- .1 Refer to demolition requirements specified in Section entitled Demolition and Revision Work.

3.2 Piping Installation Requirements

- .1 Provide required domestic water piping. Install piping in accordance with local governing codes and standards and for special piping, also follow manufacturer instructions to suit intended applications.
- .2 Piping, unless otherwise specified, is as follows:
 - .1 for pipe inside building and aboveground in sizes to 100 mm (4") dia., except in vertical shafts and through fire barriers: rigid CPVC;
 - .2 option for branch hot and cold piping aboveground from mains and risers to fixtures, fittings, and equipment where fire rated construction is not penetrated: PEX tubing installed and joined in accordance with manufacturer instructions, and installer trained and certified by manufacturer or manufacturer representative;
 - .3 for pipe inside building and aboveground in sizes to 100 mm (4") dia: Type "L" hard copper with solder joints or Type "L" hard copper with pressure coupled mechanical joints.
- .3 Lay pipes true to line and grade with bells upgrate. Fit sections together so that, when complete, pipe has smooth and uniform invert. Keep pipe thoroughly clean so jointed compound adheres. Inspect pipe for defects before being lowered into trench.
- .4 Slope piping so it can be completely drained.
- .5 Provide cast brass dielectric type adapters/unions at connections between ferrous and copper pipe or equipment.

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- .6 Clean grooved pipe ends free from indentations, projections and roll marks in area from pipe end to groove for proper gasket sealing. Provide couplings and gasket style and elastomeric material (grade) suitable for intended service in accordance with manufacturers requirements. Install in accordance with manufacturers instructions. Engage manufacturer representative to periodically visit job site to inspect work. Correct deficiencies.

3.3 Installation of Shut-Off and Check Valves

- .1 Refer to Part 3 of Section entitled Basic Mechanical Materials and Methods.
- .2 For shut off valves installed on solder joint copper piping up to and including 75 mm (3") diameter, provide ball type valves, and for flanged joints copper or stainless steel piping larger than 75 mm (3") diameter provide butterfly type valves.

3.4 Installation of Drain Valves

- .1 Provide drain valve at bottom of domestic water piping risers, at other piping low points, and wherever else shown.
- .2 Locate drain valves so they are easily accessible.

3.5 Installation of Domestic Hot Water Piping Balancing Valves

- .1 Provide balancing valves in domestic hot water recirculation piping where shown or required.
- .2 Locate each valve so it is easily accessible.

3.6 Installation of Partition Stops

- .1 Provide partition stops in domestic water piping to each group of suite washroom plumbing fixtures. Locate partition stops in piping near floor level in inconspicuous but accessible locations. Confirm exact locations prior to roughing-in.

3.7 Installation of Domestic Hot Water Thermostatic Mixing Valves

- .1 Provide domestic hot water thermostatic mixing valve assembly and wall mount.
- .2 Adjust each valve to design requirements and check and test operation. Set maximum temperature limit stops.
- .3 Identify each valve and its water temperature delivery setting with engraved nameplate.
- .4 .

3.8 Installation of Trap Seal Primers

- .1 Provide required accessible trap seal primers to automatically maintain water seal in floor drain traps, whether shown on drawings or not.
- .2 Water closet flush valves may be used for priming washroom floor drain traps if flush tube is properly tapped and primer tubing exposed in washroom is chrome plated.
- .3 Provide trap primer valves to prime single or multiple (1 to 6) traps. Install trap primer valves in domestic cold water piping to frequently used plumbing fixtures. Where from 2 to 6 traps are to be primed from same primer valve, provide appropriate supply and distribution tube assemblies. Ensure primer valves are accessible.

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- .4 Provide 115 volt, electronic, surface wall mounting trap primer assemblies for multiple (4 to 30) traps. Coordinate with Division 26 Electrical Contractor, to provide 115 volt 15 ampere panel breaker and wiring in conduit from closest panelboards to power feed primer assembly, to standards of Division 26. Adjust primer water flow and timing to suit number of traps served.
- .5 Secure trap primer piping to floor drain primer tapplings. Do not terminate through tapping in throat of drain.

3.9 Installation of Water Hammer Arrestors

- .1 Provide accessible water hammer arrestors in domestic water piping in locations as follows:
 - .1 in headers at groups of plumbing fixtures;
 - .2 at top of risers;
 - .3 at ends of long horizontal runs of piping;
 - .4 in piping connecting solenoid valves or equipment with integral solenoid valves;
 - .5 wherever else shown or required by local governing codes and standards.
- .2 Install each unit in piping tee either horizontally or vertically in path of potential water shock, in accordance with manufacturer instructions and details.

3.10 Installation of Expansion Compensators, Guides and Anchors

- .1 Provide expansion compensators in domestic water piping.
- .2 Install pipe ends properly aligned. Provide alignment guides on each side of expansion compensators, properly secured to building structure.
- .3 Provide anchors to secure domestic water piping to structure. Locate anchors generally where shown but with exact locations to suit piping as installed and requirements of reviewed anchor shop drawings.
- .4 When installation of anchors is complete, arrange, and pay for anchor design engineer to visit site to review anchor installation. Submit letter from design engineer confirming each anchor is properly installed.
- .5 For PEX installations:
 - .1 Utilize continuous support tray as resembled by piping manufacturer to mitigate thermal expansion and contraction. Natural corners and offsets may also be used. In conjunction with above options, provide anchor points every 20 m (65') for hydronic systems on continuous runs without jogs. Refer to manufacturer installation instructions.
 - .2 Piping Hanger Spacing: Install hangers for PEX piping with following maximum spacing:
 - .1 NPS $\frac{3}{4}$ (DN 20) and smaller: 815 mm (32") with 10 mm (3/8") rod;
 - .2 NPS 1 to NPS 3 (DN 25 to DN 75): 1200 mm (48") with 10 mm (3/8") rod;
 - .3 NPS 4 (DN 110) and smaller: continuously supported by PEX pipe support or metallic V-channels that:

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- .1 are supported every 1.8 m (6') for NPS $\frac{3}{4}$ (DN 20) and smaller;
- .2 are supported every 2.4 m (8') for NPS 1 to 4 (DN 25 to DN 110).
- .4 Have a maximum cantilever, measured from support to end of CTS support channel, of 0.5 m (1.5').
- .3 Riser Supports: Install CTS riser clamps at base of each floor and at top of every other floor. Install mid-story guides between each floor.

3.11 Installation of Lavatory Supply Fitting Tempering Valves

- .1 Provide thermostatic water tempering valves for hot water supply to public washroom lavatory supply fittings. Conceal valves and piping.
- .2 Provide flush wall mount panel for each valve. Confirm exact location prior to roughing-in.
- .3 Install in accordance with manufacturer instructions and set mixing valves to deliver 32°C (90°F) tempered water.

3.12 Installation of Air Vents

- .1 Provide accessible air vents in domestic water piping to prevent air binding.
- .2 Extend copper indirect drain piping from top drain connection of each vent to nearest suitable drain.
- .3 Locate exact vent locations on as-built record drawings.

3.13 Flushing and Disinfecting Piping

- .1 Flush and disinfect domestic water piping after leakage testing is complete.
- .2 Isolate new piping from existing piping prior to flushing and disinfecting procedures.
- .3 Flush piping until foreign materials are removed and flushed water is clear. Provide connections and pumps as required. Open and close valves, faucets, hose outlets, and service connections to ensure thorough flushing.
- .4 When flushing is complete, disinfect piping with solution of chlorine in accordance with AWWA C601.
- .5 When disinfecting is complete, submit water samples to certified laboratory for purity testing and, when testing indicates pure water in accordance with governing standards, submit copy of test results and fill systems.

END OF SECTION

PART 1 - GENERAL

1.1 Submittals

- .1 Submit shop drawings/product data sheets for all products specified in this Section except pipe and fittings.
- .2 Submit a copy of plumbing inspection certificate prior to application for Substantial Performance of the Work.

PART 2 - PRODUCTS

2.1 Pipe, Fittings and Joints

- .1 PVC - DWV
 - .1 Low Buildings:
 - .1 IPEX System 15 rigid PVC drain, waste and vent pipe and fittings in accordance with CAN/CSA B181.2, complete with flame spread rating not more than 25 when tested in accordance with CAN/ULC-S102.2, with solvent welded joints or MJ Grey mechanical joint couplings, and, for fire barrier penetration, approved firestop in accordance with CAN/ULC-S115.
 - .2 High Buildings and Plenums:
 - .1 IPEX System XFR rigid PVC drain, waste and vent pipe and fittings in accordance with CAN/CSA B181.2, compete with flame spread rating not more than 25 and smoke developed classification not more than 50 when tested in accordance with CAN/ULC-S102.2, with solvent welded joints or MJ Grey mechanical joint couplings, and, for fire barrier penetration, approved firestop in accordance with CAN/ULC-S115.
- .2 Copper - Solder Joint
 - .1 Type DWV hard temper to ASTM B306, with forged copper solder type drainage fittings and 50% lead - 50% tin solder joints.
- .3 Cast Iron
 - .1 Class 4000 cast iron pipe, fittings, and mechanical coupling joints to CAN/CSA B70.
- .4 Galvanized Steel - Victaulic Coupling Joint
 - .1 Schedule 40 mild steel, galvanized, ASTM A53, factory or site rolled grooved, complete with Victaulic galvanized ductile iron grooved end fittings and, unless otherwise specified, Victaulic Style 77 hot dip galvanized mechanical joint couplings with Grade M gaskets.

2.2 Cleanouts

- .1 Horizontal Piping
 - .1 TY pipe fitting with an extra heavy brass plug screwed into the fitting.
- .2 Vertical Piping

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- .1 Bronze or copper cleanout tees in copper piping, each complete with a bronze ferrule, and, for cast iron piping, "BARRETT" type cast iron cleanout tees, each gas and water-tight and complete with a bolted cover.

2.3 Floor Cleanout Terminations

- .1 Factory finished cast iron terminations, each adjustable and complete with a cast iron body with neoprene sleeve, solid, gasketed, polished nickel-bronze scoriated top access cover to suit floor finish, a seal plug, and captive, vandal-proof, stainless steel securing hardware.
- .2 Acceptable products are:
 - .1 Watts Industries (Canada) Ltd. # CO-200-R-1;
 - .2 Jay R. Smith #4020-F-C Series;
 - .3 Zurn # ZN-1602-SP Series;
 - .4 Mifab # C1100-XR-1 or #C1000-R-3.
- .3 Cleanout terminations in areas with a tile or sheet vinyl floor finish are to be as above but with a square top in lieu of a round top.

2.4 Floor Drains, Funnel Floor Drains and Hub Drains

- .1 Unless otherwise specified or indicated, floor drains are to be vandal-proof drains in accordance with drawing symbol list, each complete with a cast iron body and a trap seal primer connection. Cast iron components are to be factory finished with latex based paint coating.
- .2 Floor drains in areas with a tile or sheet vinyl floor finish are to be as above but with a square grate in lieu of a round grate.
- .3 Acceptable manufacturers are:
 - .1 Watts Industries (Canada) Ltd.;
 - .2 Jay R. Smith Manufacturing Co.;
 - .3 Zurn Industries Ltd.;
 - .4 Mifab Inc.

PART 3 - EXECUTION

3.1 Demolition

- .1 Refer to demolition requirements specified in Section entitled Demolition and Revision Work.

3.2 Drain and Vent Piping Installation Requirements

- .1 Provide required drainage and vent piping. Pipe, unless otherwise specified, as follows:
 - .1 for underground pipe inside building and to points 1.5 m (5') outside building lines – rigid PVC sewer pipe, minimum 75 mm (3") dia.;
 - .2 for pipe inside building and aboveground in sizes less than or equal to 65 mm (2-½") dia. – type DWV copper;

Drainage and Vent Piping and Specialties

- .3 for pipe inside building and aboveground in sizes greater than or equal to 75 mm (3") dia. – Class 4000 cast iron;
- .4 for pipe inside building and aboveground in lieu of type DWV copper and cast iron, at your option and where permitted by governing Codes and Regulations – rigid PVC DWV;
- .5 for drainage pump discharge pipe connections from pump to and including shut-off and check valve connections – Type "DWV" copper with Victaulic "Copper Connection" fittings and couplings, or Schedule 40 galvanized steel with Victaulic fittings and couplings.
- .2 Unless otherwise specified, slope horizontal drainage piping aboveground in sizes to and including 75 mm (3") dia. 25 mm (1") in 1.2 m (4'), and pipe 100 mm (4") dia. and larger 25 mm (1") in 2.4 m (8').
- .3 Install and slope underground drainage piping to inverts or slopes indicated on drawings to facilitate straight and true gradients between points shown. Verify available slopes before installing pipes.
- .4 Unless otherwise specified, slope horizontal branches of vent piping down to fixture or pipe to which they connect with a minimum pitch of 25 mm (1") in 1.2 m (4').
- .5 Extend vent stacks up through roof generally where shown but with exact locations to suit site conditions and in any case a minimum of 3 m (10') from fresh air intakes. Terminate vent stacks a minimum of 330 mm (13") above roof (including roof parapets) in vent stack covers. Where not shown on drawings, route vent piping from source to building exterior as required in order to satisfy local governing codes and authority. Coordinate vent routing with other building services and ensure there is no architectural impact.
- .6 Provide cast brass dielectric unions at connections between copper pipe and ferrous pipe or equipment.

3.3 Installation of Cleanouts

- .1 Provide cleanouts in drainage piping in locations as follows:
 - .1 in building drain or drains as close as possible to inner face of outside wall, and, if a building trap is installed, locate cleanout on downstream side of building trap;
 - .2 at or as close as practicable to the foot of each drainage stack;
 - .3 at maximum 15 m (50') intervals in horizontal pipe 100 mm (4") dia. and smaller;
 - .4 at maximum 26 m (85') intervals in horizontal pipe larger than 100 mm (4") dia.;
- .2 Cleanouts are to be same diameter as pipe in piping to 100 mm (4") dia., and not less than 100 mm (4") dia. in piping larger than 100 mm (4") dia.
- .3 Where cleanouts in vertical piping are concealed behind walls or partitions, install cleanouts near floor and so cover is within 25 mm (1") of the finished face of the wall or partition.

3.4 Installation of Floor Cleanout Terminations

- .1 Where cleanouts occur in horizontal inaccessible underground piping, extend cleanout TY fitting up to floor, and provide a cleanout termination set flush with finished floor.

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- .2 In waterproof floors, ensure each cleanout termination is equipped with a flashing clamp device. Cleanout terminations are to suit floor finish.
- .3 Where cleanout terminations occur in finished areas, confirm locations prior to rough-in and arrange piping to suit.
- .4 Ensure cleanout termination covers in tiled floor are square in lieu of round.

3.5 Installation of Floor Drains, Funnel Floor Drains and Hub Drains

- .1 Provide floor drains, funnel floor drains and hub drains.
- .2 Coordinate location of floor drains, funnel floor drains and hub drains with equipment provided by Mechanical Division and Owner's supplied equipment. Install in accordance with manufacturer's instructions.
- .3 Equip each drain with a trap.
- .4 In equipment rooms and similar areas, exactly locate floor drains to suit location of mechanical equipment and equipment indirect drainage piping. In washrooms, exactly locate floor drains to avoid interference with toilet partitions.
- .5 Confirm exact location of drains prior to roughing in. Where floor drains occur in washrooms coordinate locations with toilet partition installations.
- .6 Temporarily plug and cover floor drains during construction procedures. Remove plugs and covers during final clean-up work and when requested, demonstrate free and clear operation of each drain. Replace any damaged grates, and refinish any areas of the drain where cast iron finish has been damaged or removed, including rusted areas.

END OF SECTION

PART 1 - GENERAL

1.1 Submittals

- .1 Submit product data sheets (fixture cuts) for all plumbing fixtures and fittings, including accessories.
- .2 Submit fixture manufacturer's standard colour charts for fixtures where colours are available but a particular colour is not specified.

PART 2 - PRODUCTS

2.1 General Re: Plumbing Fixtures and Fittings

- .1 Fixtures and fittings, where applicable, are to be in accordance with requirements of CAN/CSA-B45 Series, General Requirements for Plumbing Fixtures, including supplements, ASME A112.1.18.1/CSA B125.1, Plumbing Supply Fittings, and CAN/CSA-B125.3, Plumbing Fittings.
- .2 Barrier-free fixtures and fittings are to be in accordance with governing Code requirements.
- .3 Unless otherwise specified, vitreous china, porcelain enamelled, and acrylic finished fixtures are to be white.
- .4 Unless otherwise specified, toilet seats are to be constructed with an anti-microbial compound to inhibit growth of bacteria on seat surface.
- .5 Unless otherwise specified, fittings and piping exposed to view are to be brass, chrome plated and polished.
- .6 Fittings located in areas other than private washrooms are to be vandal-resistant.
- .7 Fixture carriers are to be suitable in all respects for the fixture they support and construction in which they are located.
- .8 Floor flanges for floor mounted water closets are to be cast iron or brass, secured to floor to prevent movement and complete with a wax seal and brass or stainless steel bolts, nuts, and washers. Plastic floor flanges will not be acceptable.
- .9 Proper seal to mate with fixture carrier flange and produce a water-tight installation.
- .10 Exposed traps for fixtures not equipped with integral traps, such as lavatories, are to be adjustable chrome plated cast brass "P" traps with cleanouts, minimum #17 gauge chrome plated tubular extensions, and chrome plated escutcheons, all to suit fixture type and drain connection.
- .11 Concealed traps for fixtures not equipped with integral traps, such as counter sinks, are to adjustable cast brass with cleanout plugs, all to suit fixture type and drain connection.
- .12 Exposed supplies for fixtures which do not have supply trim/fittings with integral stops, i.e. lavatories, are to be solid chrome plated brass angle vales with screwdriver stops for public areas, wheel handle stops for private areas, flexible stainless steel risers, and stainless steel or chrome plated steel escutcheons, all arranged and sized to suit fixture.
- .13 Water piping as specified, complete with ball type shut-off valves as specified with water piping or Dahl Bros. Canada Ltd. ¼ turn Mini Ball Valves.

2.2 Plumbing Fixtures and Fittings

- .1 Plumbing fixtures and fittings are to be in accordance with following:

.1 HHS-1

- .1 HYTRONIC®, Counter mounted, Automatic no-touch, Hardwired, Lavatory faucet, Polished chrome finish, Single hole centerset, Lead Free ANSI/NSF 61 and ANSI/NSF 372 compliant, ECAST® brass construction, Stainless steel hoses included, 5.7 LPM (1.5 GPM) maximum flowrate, Plain end outlet with laminar flow control insert in spout inlet, Gooseneck spout, 133 mm (5-1/4") spout reach, 289 mm (11-3/8") high, Dual infrared sensor, 12 volt AC transformer required (to be ordered separately).
- .2 Hardwired AC transformer, Transformer and wire
- .3 Lead Free, with Chrome-plated finish, Wheel handle, Full turn brass stem, Purple EPDM peroxide cured washers.
- .4 Wall-hung Infection control sink, Vitreous china, EverClean® antimicrobial surface, White finish, Single hole centerset, Sealed overflow, With faucet ledge, Includes offset grid drain with Saniguard® coating, For floor-mounted carrier (by others), Removable acrylic shroud (with mounting hardware) provided,
 - .1 Overall Dimensions: 508 mm (20") long, 432 mm (17") wide, 663 mm (26-3/32") high
 - .2 Bowl Dimensions: 260 mm (10-1/4") long, 419 mm (16-1/2") wide, 235 mm (9-1/4") deep
- .5 Single, Wall Plate, Integral welded feet, Universal steel hangar support plate, Heavy gauge steel offset uprights, Plated hardware.

Healthcare Plumbing Fixtures and Fittings

570-86820 Point of Use and Master controlled fixtures, Thermostatic master water mixing control valve, Lead free brass body construction, Nickel plated finish, Lead free brass body construction, 1.9 - 30 LPM (0.5 - 8 GPM) range for flowrate, To adjust the mixed outlet temperature of the valve, remove the cap to gain access to the adjusting spindle. The spindle should be rotated-clockwise to reduce the temperature, counter-clockwise to increase the temperature until the desired set point is reached, 11 LPM (3 GPM) tempered flowrate @ 5 PSI pressure drop, The temperature is adjusted with the help of Spindle, 4-7/8" (124 mm) Height, The temperature is adjusted with the help of Spindle, 3/8" MNPT (9.5 mm) inlet, 3/8" MNPT (9.5 mm) inlet, 95-115 °F outlet water temperature range, 3/8" MNPT (9.5 mm) outlet, 3/8" MNPT (9.5 mm) outlet, internal checks, Thermostatic master water mixing control valve, Nickel plated finish, Point of Use and Master controlled fixtures, ASSE 1070 approved Certified to CSA B125.3 for ASSE 1070 applications, 95-115 °F outlet water temperature range, Offers choice of temperature settings from 95° through 115 °F., 125 PSI max hydrostatic pressure, 125 PSI max hydrostatic pressure, ±20% pressure variation, ±20% pressure variation, 11 LPM (3 GPM) tempered flowrate @ 5 PSI pressure drop, To adjust the mixed outlet temperature of the valve, remove the cap to gain access to the adjusting spindle. The spindle should be rotated-clockwise to reduce the temperature, counter-clockwise to increase the temperature until the desired set point is reached, 40-80 °F, 10 °F, 180 °F max, 7 GPM flowrate @ 45 PSI, Offers choice of temperature settings from 95° through 115 °F., ±5 °F, Protects against scalding and chilling.

- .6 Cast brass body material, Chrome-plated finish, 1-1/4x1-1/2 p- trap, 304 mm (12") length, With cleanout plug, Steel box flange, Neoprene gasket, Slipnuts, 17 gauge seamless tubular wall bend.

.2 WC-1

- .1 FAST-N-LOCK, For elongated bowl, Open front, Heavy-duty, For commercial applications, Polypropylene, Toilet seat, Less seat cover, Self-sustaining plastic commercial check hinges, and Stainless steel hinge pin, Specified in White finish, and Antimicrobial additive inhibits the growth of stain and odor causing bacteria, FAST-N-LOCK mounting system takes the guess work out when tightening the hardware. The specially designed fasteners in click" when the appropriate torque is reached. The bolt and nut material shall be stainless steel,
 - .1 Dimensions: 25 mm (1") high, 473 mm (18-5/8") long, 371 mm (14-5/8") wide

Healthcare Plumbing Fixtures and Fittings

- .2 SL-ROYAL 111-1.28 SG ROYAL® Manual Exposed Water closet flushometer, 38 mm (1-1/2") spud coupling For top spud toilet, constructed from Semi-red brass, Polished chrome finish, High Efficiency 4.8 LPF (1.28 GPF), Chloramine resistant PERMEX® synthetic rubber diaphragm, Saniguard® coated metal oscillating handle, Flush tube for 292 mm (11-1/2") rough-in, Adjustable tailpiece, 25 mm (1") I.P.S. screwdriver Bak-Chek® angle control stop with free spinning vandal- resistant stop cap, Dual-filtered fixed bypass, Sweat solder adapter kit with cover tube, High back pressure vacuum breaker, Inlet located right of valve, 25 mm (1") supply pipe, Cast wall flange with set screw, Non-hold-open, no external volume adjustment, fixed volume accuracy is controlled by CID™ technology. Pressure Range: 103 - 552 kPa (15 - 80 PSI) operating water pressure Compliances: Requires less than 5 pounds of force to activate (push button), cUPC compliant.
 - .3 Toilet, Wall-hung with wall outlet, Toilet operates in the range of 4.2 to 6.0 LPF (1.1- 1.6 GPF), White finish Vitreous china, EverClean® antimicrobial surface, Elongated bowl, Concealed trapway design, Direct-fed siphon jet flush action, 38 mm (1-1/2") top spud, Flush valve by others, Fully-glazed 54 mm (2-1/8") trapway, Static load rating of 454 kg (1000 lb), this product is not recommended for bariatric use, Condensation channel, Toilet seat not included, Consisting of:
 - .1 Overall Dimensions: 356 mm (14") wide, 660 mm (26") from finished wall,
 - .2 Water Surface: 254 x 305 mm (10" x 12") water surface area
 - .3 Map Score: >=1000 MaP® flush score (when use with proper flush valve) Compliances: ASME A112.19.2 compliant, CSA B45.1 compliant.
 - .4 Industry Standard single Horizontal adjustable Closet Carrier, Adjustable for standard and wheelchair height, 102 mm (4") no hub waste, 51 mm (2") no hub vent connections, patented compression seal faceplate assembly, epoxy coated cast iron, with incremental measurements embossed onto legs to easily adjust height of carrier to most commonly used fixture requirements, epoxy coated cast iron foot support, neoprene bowl gasket, epoxy coated cast iron, integral test cap, chrome cap nuts, Plated hardware, Adjustable ABS nipple. Codes and Compliances: Carrier complies with requirements of ASME A112.6.1M up to a 500 lb (227 kg) static load.
- .3 L1
- .1 Counter mounted, Manual, Two handles, Sink faucet, Chrome-plated finish, 203 mm (8") centerset, Lead Free ANSI/NSF 61 and ANSI/NSF 372 compliant, ECAST® brass construction, -377-XKAB ceramic 1/4 turn cartridge, 5.7 LPM (1.5 GPM) maximum flowrate, -FC 5.7 LPM (1.5 GPM) laminar flow control insert in spout inlet, plain end outlet, Gooseneck spout, 203 mm (8") spout reach, -317-PR vandal-resistant 102 mm (4") metal wrist blade handles with red & blue index, Grid drain included, 13 mm (1/2") NPSM supply inlet for 10 mm (3/8") or 13 mm (1/2") flexible riser.

Healthcare Plumbing Fixtures and Fittings

- .2 Point of Use and Master controlled fixtures, Thermostatic master water mixing control valve, Lead free brass body construction, Nickel plated finish, Lead free brass body construction, 1.9 - 30 LPM (0.5 - 8 GPM) range for flowrate , To adjust the mixed outlet temperature of the valve, remove the cap to gain access to the adjusting spindle. The spindle should be rotated-clockwise to reduce the temperature, counter-clockwise to increase the temperature until the desired set point is reached, 11 LPM (3 GPM) tempered flowrate @ 5 PSI pressure drop, The temperature is adjusted with the help of Spindle, 4-7/8" (124 mm) Height, The temperature is adjusted with the help of Spindle, 3/8" MNPT (9.5 mm) inlet, 3/8" MNPT (9.5 mm) inlet, 95-115 °F outlet water temperature range, 3/8" MNPT (9.5 mm) outlet, 3/8" MNPT (9.5 mm) outlet, internal checks, Thermostatic master water mixing control valve, Nickel plated finish, Point of Use and Master controlled fixtures, ASSE 1070 approved Certified to CSA B125.3 for ASSE 1070 applications, 95-115 °F outlet water temperature range, Offers choice of temperature settings from 95° through 115 °F., 125 PSI max hydrostatic pressure, 125 PSI max hydrostatic pressure, ±20% pressure variation, ±20% pressure variation, 11 LPM (3 GPM) tempered flowrate @ 5 PSI pressure drop, To adjust the mixed outlet temperature of the valve, remove the cap to gain access to the adjusting spindle. The spindle should be rotated-clockwise to reduce the temperature, counter-clockwise to increase the temperature until the desired set point is reached, 40-80 °F, 10 °F, 180 °F max, 7 GPM flowrate @ 45 PSI, Offers choice of temperature settings from 95° through 115 °F., ±5 °F, Protects against scalding and chilling
- .3 Wall-hung Lavatory, Vitreous china, EverClean® antimicrobial surface, White finish, 203 mm (8") centerset, Less overflow, Faucet ledge with recessed self-draining deck, For concealed arm or wall support, Acrylic shroud, conceals control box and thermostatic mixing valve (0097000), Soap dispenser, When installed with a below deck electronics faucet which has the control box, the accessories will not fit under the shroud and will need to be installed outside the shroud,
 - .1 Overall Dimensions: 545 mm (21-7/16") long, 540 mm (21-1/4") wide, 152 mm (6") high
 - .2 Bowl Dimensions: 343 mm (13-1/2") long, 394mm (15-1/2") wide, 127 mm (5") deep
- .4 **PRODRAINSAN** SANIGUARD treated grid drain less overflow, Straight drain, Heavy cast brass, Chrome-plated finish, Saniguard inorganic antimicrobial compound, Less overflow, Seamless brass material, 17 gauge 32 mm (1-1/4") Ø tailpiece diameter, 17 gauge 152 mm (6") long tailpiece
- .5 Lead Free, with Chrome-plated finish, Wheel handle, Full turn brass stem, Purple EPDM peroxide cured washers.
- .6 Cast brass body material, Chrome-plated finish, 1-1/4x1-1/4 p- trap, 279 mm (11") distance, With cleanout plug, Steel box flange, Neoprene gasket, Slipnuts, 17 gauge seamless tubular wall bend

Healthcare Plumbing Fixtures and Fittings

- .7 WCA-411/WCA-411-WC, Single floor-mounted lavatory carrier with concealed arms, For concealed arm carrier, adjustable arms, epoxy coated cast iron, integral welded feet, upper tie rod, Heavy gauge steel offset uprights, basin locking device, Plated hardware, levelling screws, Wall mounted steel support plate with plated hardware.
- .4 S-1
 - .1 Counter mounted, Manual, Two handles, Sink faucet, Chrome-plated finish, 203 mm (8") centerset, Lead Free ANSI/NSF 61 and ANSI/NSF 372 compliant, ECAST® brass construction, -377-XKAB ceramic 1/4 turn cartridge, 5.7 LPM (1.5 GPM) maximum flowrate, -FC 5.7 LPM (1.5 GPM) laminar flow control insert in spout inlet, plain end outlet, Gooseneck spout, 203 mm (8") spout reach, -317-PR vandal-resistant 102 mm (4") metal wrist blade handles with red & blue index, Grid drain included, 13 mm (1/2") NPSM supply inlet for 10 mm (3/8") or 13 mm (1/2") flexible riser.
 - .2 Point of Use and Master controlled fixtures, Thermostatic master water mixing control valve, Lead free brass body construction, Nickel plated finish, Lead free brass body construction, 1.9 - 30 LPM (0.5 - 8 GPM) range for flowrate , To adjust the mixed outlet temperature of the valve, remove the cap to gain access to the adjusting spindle. The spindle should be rotated-clockwise to reduce the temperature, counter-clockwise to increase the temperature until the desired set point is reached, 11 LPM (3 GPM) tempered flowrate @ 5 PSI pressure drop, The temperature is adjusted with the help of Spindle, 4-7/8" (124 mm) Height, The temperature is adjusted with the help of Spindle, 3/8" MNPT (9.5 mm) inlet, 3/8" MNPT (9.5 mm) inlet, 95-115 °F outlet water temperature range, 3/8" MNPT (9.5 mm) outlet, 3/8" MNPT (9.5 mm) outlet, internal checks, Thermostatic master water mixing control valve, Nickel plated finish, Point of Use and Master controlled fixtures, ASSE 1070 approved Certified to CSA B125.3 for ASSE 1070 applications, 95-115 °F outlet water temperature range, Offers choice of temperature settings from 95° through 115 °F., 125 PSI max hydrostatic pressure, 125 PSI max hydrostatic pressure, ±20% pressure variation, ±20% pressure variation, 11 LPM (3 GPM) tempered flowrate @ 5 PSI pressure drop, To adjust the mixed outlet temperature of the valve, remove the cap to gain access to the adjusting spindle. The spindle should be rotated-clockwise to reduce the temperature, counter-clockwise to increase the temperature until the desired set point is reached, 40-80 °F, 10 °F, 180 °F max, 7 GPM flowrate @ 45 PSI, Offers choice of temperature settings from 95° through 115 °F., ±5 °F, Protects against scalding and chilling
 - .3 Without faucet ledge, 18 gauge Type 316 Stainless steel Polished to #4 satin finish, Factory installed EZ TORQUE™ fasteners, Factory applied rim seal, Center back waste location, 38 mm (1-1/2") (DN38) type 316 stainless steel tailpiece, 89 mm (3- 1/2") type 316 stainless steel crumb cup strainer, waste fittings included, Undercoated to reduce condensation and resonance, Codes and Compliances: ASME A112.19.3 compliant, CSA B45.4 compliant,
 - .1 Bowl Dimension: 406 mm (16") long, 356 mm (14") wide, 254 mm (10") deep,
 - .2 Overall Dimension: 460 mm (18-1/8") long, 410 mm (16-1/8") wide, 254 mm (10") high.

Healthcare Plumbing Fixtures and Fittings

- .4 Lead Free, with Chrome-plated finish, Wheel handle, Full turn brass stem, Purple EPDM peroxide cured washers.
- .5 Cast brass body material, Chrome-plated finish, 1-1/2x1-1/2 p- trap, 304 mm (12") length, With cleanout plug, Steel box flange, Neoprene gasket, Slipnuts, 17 gauge seamless tubular wall bend

2.3 Acceptable Manufacturers

- .1 Subject to compliance with requirements, manufacturers that may be incorporated into the Work include, but are not limited to, following:
 - .1 Flush Valves:
 - .1 Sloan.
 - .2 Delta Commercial.
 - .3 Zurn Industries.
 - .2 Plumbing Brass:
 - .1 Sloan.
 - .2 Acorn Engineering.
 - .3 American Standard.
 - .4 Delta Commercial.
 - .5 Chicago Faucet.
 - .3 Stainless Steel Sinks:
 - .1 Franke Commercial.
 - .2 Novanni Commercial.
 - .3 Aristaline.
 - .4 Arch Metal Ind.
 - .4 Mop Sinks:
 - .1 Stern Williams.
 - .2 Acorn Engineering.
 - .3 Zurn Industries.
 - .5 Emergency Eye Wash and Emergency Showers:
 - .1 Haws.
 - .2 Speakman.
 - .3 Bradley.
 - .6 Bariatric Water Closets:
 - .1 Jay R. Smith.
 - .2 Acorn Engineering.

Healthcare Plumbing Fixtures and Fittings

- .3 Zurn Industries.
- .7 Drain Fittings, Angle Supplies, and Traps:
 - .1 McGuire.
 - .2 American Standard.
 - .3 Delta Commercial.
 - .4 Zurn Industries.
- .8 Fixture Carriers:
 - .1 Watts Industries.
 - .2 Jay R. Smith.
 - .3 Zurn Industries.
- .9 Surgeon Scrub Sinks:
 - .1 Franke Commercial.
 - .2 Acorn Engineering.
- .10 Hose Bibbs:
 - .1 Jay R. Smith.
 - .2 Zurn Industries.
- .11 Water Closets, Lavatories, and Urinal:
 - .1 American Standard.
 - .2 Zurn Industries.
 - .3 Kohler.
- .12 Thermostatic Mixing Valves:
 - .1 Lawler.
 - .2 Delta Commercial.
 - .3 Leonard.
- .13 Shower and Associated Trim:
 - .1 American Standard.
 - .2 Delta Commercial.
 - .3 Zurn Industries.
- .14 Toilet Seats:
 - .1 Olsonite.
 - .2 Centoco.
 - .3 Bemis Commercial.
- .15 Electronic "No Touch" Flush Valves:
 - .1 Sloan.

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- .2 Delta Commercial.
- .3 Zurn Industries.
- .16 Electronic "No Touch" Faucets:
 - .1 Sloan.
 - .2 Delta Commercial.
 - .3 Zurn Industries.

2.4 Caulking

- .1 General Electric Series SCS-1200 Silicone Construction Sealant or Dow Corning 780 silicone rubber sealant with primers as recommended by sealant manufacturer. Caulking colour(s) for coloured fixtures other than white, if any, will be selected by Consultant from sealant manufacturer's standard colour range.
- .2 Caulking in Mental Health areas shall be pick proof.

PART 3 - EXECUTION

3.1 Demolition

- .1 Refer to demolition requirements specified in Section entitled Demolition and Revision Work.

3.2 Installation of Plumbing Fixtures and Fittings

- .1 Provide required plumbing fixtures and fittings.
- .2 Where new fixtures and fittings are to be connected to existing piping, include for required piping revisions.
- .3 Connect plumbing fixtures and fittings with piping sized in accordance with drawing schedule. Refer to manufacturer's published connection (rough-in) requirements. Where manufacturer requires piping connection larger than shown below, provide piping accordingly:

FIXTURE AND/OR FITTING	DRAIN SIZE MM (IN.)	VENT SIZE MM (IN.)	DHW SIZE MM (IN.)	DCW SIZE MM (IN.)	TEMP WATER SIZE MM (IN.)
Water Closets Flush Valve Type	100 (4)	38 (1-½)	-----	25 (1)	-----
Urinals	75 (3)	38 (1-½)	-----	25 (1)	-----
Lavatories	32 (1-¼)	32 (1-¼)	12 (½)	12 (½)	-----
Lavatories (Electronic Faucet)	32 (1-¼)	32 (1-¼)	12 (½)	12 (½)	12 (½)
Counter Sinks	38 (1-½)	32 (1-¼)	12 (½)	12 (½)	-----

Healthcare Plumbing Fixtures and Fittings

FIXTURE AND/OR FITTING	DRAIN SIZE MM (IN.)	VENT SIZE MM (IN.)	DHW SIZE MM (IN.)	DCW SIZE MM (IN.)	TEMP WATER SIZE MM (IN.)
Shower Valves and Heads	-----	-----	12 (½)	12 (½)	12 (½)
Shower Stalls	50 (2)	38 (1-½)	12 (½)	12 (½)	12 (½)
Prefab. Mop Sinks with Drain	75 (3)	38 (1-½)	20 (¾)	20 (¾)	-----
Surgeon Scrub Sinks	38 (1-½)	32 (1-¼)	20 (¾)	20 (¾)	-----
Emergency Eye Wash	-----	-----	-----	-----	12 (½)
Emergency Shower	-----	-----	-----	-----	25 (1)
Clinic Service Sinks	100 (4)	38 (1-½)	12 (½)	1 @ 25 (1) 1 @ 12 (½)	-----

- .4 Confirm exact location of plumbing fixtures and trim prior to roughing-in. Refer to architectural plan and elevation drawings.
- .5 When installation is complete, check and test operation of each fixture and fitting. Adjust or repair as required.
- .6 For barrier-free fixtures, comply with mounting height and other requirements of governing Code(s).
- .7 Supply templates for counter mounted fixtures and trim and hand to trades who will cut the counter. Ensure openings in counter are properly located.
- .8 Locate control panels for electronic faucets under lavatories and recessed into wall. Coordinate panel installations with electrical trade who will provide 115 volt power wiring to panels. Install flexible conduit (supplied with box) and extend cord from faucet through the flexible conduit to control box. Connect hot and cold water piping to mixing valve in each box, and tempered water piping from each mixing valve to faucet. Set mixing valve maximum temperature limit stops to 43°C (110°F) after domestic water systems (hot and cold) are complete. Ensure each programmable controller is properly programmed and water off after deactivation is set for 3 seconds.
- .9 Confirm exact mixing valve and shower head locations prior to roughing-in.
- .10 Install refrigerated drinking fountains in accordance with manufacturer's instructions. Plug into a wall receptacle provided as part of electrical work. Coordinate receptacle installation with electrical trade on site.

Healthcare Plumbing Fixtures and Fittings

- .11 Wall mount mixing valves for emergency fixtures approximately 1.5 m (5') above floor and secure in place. Check and confirm valve operation and temperature of tempered water supply. Provide cabinets where shown. Identify each cabinet and hand 3 identified cabinet keys to Consultant prior to Substantial Performance of the Work.

3.3 Caulking at Plumbing Fixtures and Fittings

- .1 Caulk around plumbing fixtures and fittings where they contact walls, floors, and any other building surface.
- .2 Clean areas/surfaces to be caulked and prime in accordance with sealant manufacturer's instructions. Where damage to a building surface may occur, mask surface to prevent damage and ensure a clean exact edge to caulking bead.
- .3 Apply caulking using a gun with proper size and shape of nozzle and force sealant into joints to ensure good surface contact and a smooth and even finished bead of sealant.
- .4 If joints have been masked sealant may be tooled in a continuous stroke to obtain complete void filling. Remove masking tape immediately after tooling and before sealant begins to skin.

END OF SECTION

Medical Gas Piping Systems

PART 1 - GENERAL

1.1 Submittals

- .1 Submit shop drawings/product data sheets for all products specified in this Section except pipe and fittings. Appropriate CRN assigned to each component is to be clearly indicated on component shop drawing/product data sheet.
- .2 Submit product data sheets for motors, and certified wiring diagrams for equipment requiring power, control and/or alarm wiring connections.
- .3 Submit, prior to work commencing on site, a detailed account of proposed pipe joint brazing procedures including pre- and post-nitrogen purging.
- .4 Submit written certification by equipment manufacturers/suppliers confirming equipment is properly installed, has been tested, and is in proper operating condition, all as specified in Part 3 of this Section.
- .5 Submit manufacturer's start-up reports as specified in Part 3 of this Section.
- .6 Submit 3 identified keys for cabinet/panel lockable doors prior to Substantial Performance of the Work.
- .7 For each zone valve box assembly and combination zone valve box and alarm, submit for review a typed list of rooms and areas with medical gas terminal units controlled by each zone valve.
- .8 Submit record as-built drawings in accordance with requirements specified in Section entitled Mechanical Work General Instructions.

1.2 Design Pressure and Temperature Requirements

- .1 System design pressures are as follows:
 - .1 oxygen, carbon dioxide, nitrous oxide, medical air:
 - .1 maximum system pressure, 380 kPa (55 psi);
 - .2 maximum pressure at terminal unit, 345 kPa (50 psi).
 - .2 vacuum:
 - .1 minimum system vacuum, -54 kPa (-15.94 "Hg);
 - .2 maximum vacuum at terminal unit, -68 kPa (-20.08 "Hg).
- .2 Design temperature for all services will be ambient temperature.

1.3 Quality Assurance

- .1 Products and work must comply in all respects with requirements of CAN/CSA Z7396.1 and related Standards, and, where applicable, requirements of local governing authorities.
- .2 Contractor is responsible for registration, inspection, and/or approval for medical gas system work, as required, with local regulatory authority.

Medical Gas Piping Systems

- .3 Medical gas systems work must be performed by journeyman plumber / pipefitter / steamfitter tradesmen completely familiar with requirements of CAN/CSA Z7396.1, and who are qualified and certified (with jurisdictional authority issued Certificate) for silver brazing with nitrogen backing without using flux in accordance with Clause 4.5 in Part 1 of CSA B51. Jurisdictional authority is the authority designated by the province of the work to perform oversight functions cited in Clause 4.5 in Part 1 of CSA B51.
- .4 Consultant reserves right to ask for and review Certificate of any tradesman, and only tradesmen with valid Certificates may perform work on systems.

PART 2 - PRODUCTS

2.1 General Re: Piping System Materials and Components

- .1 Pipe, fittings, and piping system components are to be factory washed and degreased. Pipe is to be capped. Fittings and components are to be packaged.
- .2 Piping system components to be site connected with piping are to be complete with factory installed, washed, degreased and capped Type "K" hard copper piping stubs with joints silver brazed while component and piping is full of nitrogen.
- .3 Unless otherwise specified, acceptable medical gas system product manufacturers/suppliers are:
 - .1 Class 1 Inc.;
 - .2 Amico Corp.;
 - .3 Vitalaire.

2.2 Pipe, Fittings and Joints

- .1 Aboveground
 - .1 Type "L" or type "K" (as specified in Part 3) hard temper copper tubing to ASTM B819, "Standard Specification for Seamless Copper Tube for Medical Gas Systems", complete with wrought copper, brass or bronze "Silver Braze" fittings and silver brazed joints made with Silvaloy 15 or equal brazing alloy conforming to ANSI/AWS Standard A5.8 Classification BcuP-5.
- .2 Underground
 - .1 Type "K" soft temper copper tubing to ASTM B88, factory cleaned and capped as for hard temper copper tubing, and supplied in a continuous length with no joints.

2.3 Shut-Off Valves

- .1 Full flow bronze body ball type valves, 4140 kPa (600 psi) rated, ¼ turn on-off from a fully closed to a fully open position, in-line serviceable, blow-out proof, factory pressure tested, and complete with a chrome plated brass or stainless steel ball depending on valve size, a double Teflon seal, a Teflon seat, O-ring packing, lever handle capable of locking in open or closed position, and colour coded permanent identification labels.

2.4 Zone Valve Boxes

Medical Gas Piping Systems

- .1 Wall mounting enamelled steel zone valve boxes with anchor brackets, sized to suit number of valves in box, designed for vertical ganging type installation and complete with shut-off valves as specified above (less the handle lock feature), securely mounted to back of box, and complete with:
 - .1 stainless steel or matte finish extruded aluminium trim;
 - .2 re-installable front panel or window with centre mounted pull ring and silk-screen bilingual wording to read "CAUTION: MEDICAL GAS CONTROL VALVE - CLOSE ONLY IN EMERGENCY";
 - .3 gauge connection brazed onto pipe stub at downstream (patient) side of each valve assembly, with a 40 mm (1-½") diameter pressure (or vacuum) gauge conforming to requirements specified in Section entitled Basic Mechanical Materials and Methods, and with ranges as follows:
 - .1 vacuum – 0 to 760 kPa (0 to 30 "Hg);
 - .2 all other services – 0 to 700 kPa (0 to 100 psi).

2.5 Local Emergency Alarm Panel/Zone Valve Box Assemblies

- .1 Flush wall mounting combination zone valve box and local emergency alarm panels and zone valve box assemblies incorporating a zone valve box and an area alarm panel in one enclosure. Each assembly is to be complete with:
 - .1 enamelled steel box sized to suit components installed, complete with adjustable steel mounting brackets to accommodate various wall thicknesses, an anodized aluminium frame, and pull-out removable window with silk-screen bilingual wording to read "CAUTION: MEDICAL GAS CONTROL VALVES - CLOSE VALVES ONLY IN EMERGENCY";
 - .2 ball type shut-off valves as specified in this Section but less the handle lock feature, sized as shown, complete with tube extensions, and secured to back of box;
 - .3 gauge connection brazed onto pipe stub at downstream (patient) side of each valve assembly, with a 40 mm (1-½") diameter pressure (or vacuum) gauge conforming to requirements specified in Section entitled Basic Mechanical Materials and Methods, and with ranges as follows:
 - .1 vacuum – 0 to 100 kPa (0 to 28.5 "Hg);
 - .2 all other services – 0 to 700 kPa (0 to 100 psi).
 - .4 modular, microprocessor-based, gas specific alarm units with large LED universal (psi, kPa, "Hg, Bar) pressure/vacuum displays, LED trend display, high and low alarms with dry contacts for connection to a master alarm panel, 90 dBA audible alarm with silence button and adjustable alarm reminder, alarm history recall, identified sensors with DISS connection located in back box, and required remote monitoring hardware.

2.6 Pressure and Vacuum Switches For Alarm Signals

Medical Gas Piping Systems

- .1 Factory assembled and set (to suit site requirements) switches, each labelled for intended service, each suitable for pipeline pressure, medical gas or vacuum involved, and alarm function, and each complete with a NEMA 4 housing, tamper-proof external adjustment, a gas specific DISS inlet, a 50 mm (2") diameter monitoring gauge in accordance with requirements specified in Section entitled Basic Mechanical Materials and Methods, and instructions for field adjustment.

2.7 Local Emergency Alarm Panels

- .1 Modular, field expandable, 115 volt, solid-state, microprocessor controlled, electronic, flush wall mounting audio-visual alarm panels designed for constant monitoring of piping system pressure or vacuum as applicable, and initiation of an alarm function on any open circuit only. Each panel is to be complete with:
 - .1 minimum #18 gauge steel back box sized to suit gas service modules required and equipped with adjustable mounting brackets to accommodate different wall thicknesses, a 115 volt power connection terminal block, fused 24 volt secondary transformer, a motherboard for plug-in connection of modules, and matte finish extruded aluminium or equal trim;
 - .2 power module with green power on LED, audible alarm with silencing pushbutton, adjustable (2 to 60 minutes) alarm repeater;
 - .3 gas specific colour coded sensors and displays with an error message for incorrect connection, each equipped with a microprocessor, LED digital readout in switch selected psi or kPa to facilitate a constant indication of each service being measured, a bar graph trend indicator to indicate green "NORMAL", yellow "CAUTION", and red "HIGH" or "LOW" alarm condition;
 - .4 red alarm light which flashes and an audible alarm which sounds when an alarm condition occurs, and an "ALARM MUTE" pushbutton to silence audible alarm, however, panel will remain in alarm state until problem is rectified;
 - .5 "TEST" pushbutton to test all panel functions;
 - .6 dry contacts for remote monitoring of high and low alarms;
 - .7 gas specific DISS connection (DISS body with check valve and DISS nut and gland) for each sensor module, supplied loose for field installation;
 - .8 building automation system serial communications interface panel.

2.8 Master Alarm Panel

- .1 Modular, field expandable, 115 volt, solid state, electronic, microprocessor-based flush wall mounting audio-visual alarm panel designed for constant monitoring of piping system pressure or vacuum as applicable, and initiation of an alarm function on any open circuit only. Panel is to be complete with:
 - .1 minimum #18 gauge steel back box sized to suit gas service modules required and equipped with adjustable mounting brackets to accommodate different wall thicknesses, a 115 volt power connection terminal block, fused 24 volt secondary transformer, a motherboard for plug-in connection of modules, and matte finish extruded aluminium or equal trim;
 - .2 power module with green power on LED, and adjustable (2 to 30 minutes) alarm repeater;

Medical Gas Piping Systems

- .3 microprocessor-based, field adjustable modules, each capable of handling 10 functions, capable of field upgrading to interface with a building automation system or slave alarm, and supplied in quantities to connect alarms as follows:
 - .1 Oxygen System:
 - .1 Primary liquid level low.
 - .2 High line pressure.
 - .3 Reserve supply in use.
 - .4 Bulk supply main tank(s) liquid level low, and cylinder reserve supply low, or, for systems with secondary liquid tanks for reserve supply, bulk supply main tank(s) liquid level low, reserve supply liquid level low, and reserve supply head pressure low, as applicable.
 - .5 Low line pressure.
 - .2 Vacuum System:
 - .1 Vac Lag/Failure (for each pump).
 - .2 Vac Transformer Failure.
 - .3 Vac Pump Electrical Overload.
 - .4 Vac High Temperature.
 - .5 Vac PLC Failure.
 - .6 Vac Low Line Pressure.
- .4 red alarm LED's which flash and an audible alarm buzzer in excess of 90 dB which sounds when an alarm condition occurs, and an "ALARM MUTE" pushbutton to silence audible alarm, however, panel will remain in alarm state until problem is rectified;
- .5 "TEST" pushbutton to test all panel functions;
- .6 dry contacts for remote monitoring of high and low alarms;
- .7 building automation system signal interface panel.

2.9 Terminal Units

- .1 DISS type, gas specific, non-interchangeable, modular, flush mounting terminal units, either singular or in groups as shown on drawings, each designed to accommodate mounting surface thickness variations of up to 12 mm ($\frac{1}{2}$ "), complete with a CRN and following:
 - .1 die-cast outlet box;
 - .2 cartridge type primary check valve and stainless steel ball type secondary check valve;
 - .3 chrome plated brass outlet body with permanently embossed gas identification nameplate with bilingual labelling, all sealed behind a protective cover with chrome plated trim;
 - .4 required centreline spacing between multiple terminal units;
 - .5 temporary protective covers, and standing pressure test caps.

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- .2 Equipment Connection Terminal Units: DISS medical gas specific riser assemblies, factory cleaned and capped, complete with a protective dust cap, brass outlet body, Type "K" inlet supply tube and bulkhead mounting provision.

2.10 Diss Conversion Terminal Units

- .1 DISS conversion assemblies, each to suit type of existing outlet to be converted, and each complete with a primary check valve, secondary check valve, and faceplate as specified for new terminal units.

PART 3 - EXECUTION

3.1 Demolition

- .1 Perform required medical gas system demolition work. Refer to Section entitled Demolition and Revision Work for demolition requirements.

3.2 General Re: Piping Installation

- .1 Perform pipe joint brazing work in accordance with CAN/CSA Z7396.1 and reviewed brazing procedures submitted to Consultant prior to start of work.
- .2 Consultant reserves right to cut-out and examine piping joints during course of work or after work is complete, and if interior of cut-out sample and/or fittings are found to be contaminated with oxidation or any other material, piping will be considered unacceptable and must be cleaned or replaced.
- .3 Where low pressure connecting assemblies are used in retractable gas columns, articulating arms, or any other dispensing assembly, DISS body or terminal unit which is used to connect it to copper pipeline must be brazed to piping system.
- .4 Refer to architectural drawing plans and elevations for exact locations of terminal units, zone valve boxes, alarm panels, and other such items.

3.3 Installation of Medical Gas System Piping

- .1 Provide required medical gas system piping. Unless otherwise shown or specified, vacuum piping is to be minimum 20 mm ($\frac{3}{4}$ ") diameter, and piping for all other services is to be minimum 12 mm ($\frac{1}{2}$ ") diameter.
- .2 Piping aboveground, unless otherwise specified, is to be Type "L" hard copper.
- .3 Provide threaded piping unions at piping connections to source equipment. Do not silver braze unions. Braze a male NPT adaptor on end of pipe, wrap Teflon tape onto adaptor (2 threads back), and screw union as tight as possible by hand, then with proper wrenches for final tightening. Do not over tighten.
- .4 Perform pipe brazing operations in strict accordance with requirements of CAN/CSA Z7396.1.
- .5 Ensure tools used during erection of piping systems are kept clean and free from oil and grease.
- .6 Support piping by means of support materials specified in Section entitled Basic Mechanical Materials and Methods, in accordance with requirements of article entitled "Pipeline Supports" in CAN/CSA Z7396.1 and with support spacing in accordance with table entitled "Spacing of Piping Supports" in CAN/CSA Z7396.1.

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- .7 Prepare a separate set of as-built white prints on a daily basis. Identify piping system work, including valves, concealed and exposed, in accordance with requirements of CAN/CSA Z7396.1. Submit record as-built drawings in accordance with requirements in Section entitled Mechanical Work General Instructions.
- .8 Install vacuum piping sloped to low points. Equip each low point, including bottom of vertical risers, with drip pockets consisting of a full size pipe tee with one leg capped with a removable cap. Ensure drip points are accessible and indicated on as-built record drawings.
- .9 Provide DISS identified riser outlet piping connections in ceiling and/or wall spaces for connection to terminal outlets integral with manufactured equipment such as articulated arms (with riser plates) provided as part of this Section of the work or as part of the work of other Divisions of the Specification. Terminal units will be pre-piped by equipment manufacturer to an accessible location. Carefully rough-in piping and coordinate equipment connections, particularly for flush mounted and/or ceiling mounted equipment.
- .10 Provide identified piping connections to ceiling columns and/or headwalls provided as part of this Section or as part of the work of other Divisions.
- .11 Provide valved and capped connections for future extension. Clearly and permanently identify each capped connection and ensure they are exactly located on as-built record drawings.
- .12 In accordance with CAN/CSA Z7396.1, provide a full size branch tee with shut-off valve for each gas source (including vacuum) downstream of main isolation valve.
- .13 Perform revision/retrofit work as shown and in accordance with CAN/CSA Z7396.1.

3.4 Installation of Valves

- .1 Provide shut-off/isolation valves where shown and/or required by CAN/CSA Z7396.1. Shut-off valves, unless otherwise specified, are to be ball type.
- .2 Provide check valves where shown and/or required by CAN/CSA Z7396.1.
- .3 Ensure valves are located for easy access and operation.

3.5 Installation of Zone Valves And Boxes

- .1 Provide zone valves in zone valve boxes. Provide a service isolation valve in piping immediately upstream of each zone valve and on same floor.
- .2 Accurately install boxes with reference to wall finish, and confirm exact locations prior to roughing-in.
- .3 At each zone valve box location provide a typed, framed, and glazed list of all rooms and areas controlled by each zone valve. Submit lists and wording for review prior to framing and glazing.

3.6 Installation of Combination Zone Valve/Area Alarm Boxes

- .1 Provide combination zone valve box/area alarm assemblies. Provide a service isolation valve in piping immediately upstream of each zone valve and on same floor.
- .2 Accurately install boxes with reference to wall finish, and confirm exact locations prior to roughing-in.

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- .3 At each zone valve box location provide a typed, framed and glazed list of all rooms and areas controlled by each zone valve. Submit lists and wording for review prior to framing and glazing.

3.7 Installation of Pressure/Vacuum Switches

- .1 Provide pressure or vacuum switches, as applicable, and all required connection hardware for medical gas pressure or vacuum alarms. Install in piping tees in accessible locations. Refer to tables entitled "Alarm Requirements for Cylinder and Vessel-Based Supply Systems" and "Alarm Requirements for Mechanical Supply Systems" in CAN/CSA Z7396.1.
- .2 Adjust each switch in accordance with manufacturer's/supplier's instructions to suit site and system conditions.

3.8 Installation of Alarm Panels

- .1 Provide wall mounted medical gas pressure/vacuum alarm panels. Confirm exact panel locations prior to roughing-in. Refer to architectural drawings.
- .2 Provide required hardware and connect each panel with required medical gas/vacuum piping as applicable.
- .3 Carefully check panel pressure/vacuum readings and make any required adjustments.
- .4 When installation is complete, test each panel function, and make any adjustments and corrections necessary.

3.9 Installation of Terminal Units

- .1 Provide wall mounted medical gas terminal units, either singular or in groups as indicated. Leave temporary caps in place.
- .2 Confirm exact locations prior to roughing-in. Refer to architectural drawings.
- .3 Equip each terminal unit with a faceplate.
- .4 Supply medical gas terminal units for factory installation in consoles, headwalls, articulating arms, ceiling service columns, and other such manufactured assemblies, and ship terminal units to manufacturer's plant.

3.10 Installation of Conversion Kits For Existing Terminal Units

- .1 Provide conversion kits to convert existing quick-connect terminal units to DISS terminal units.
- .2 Ensure converted terminal units are certified as part of system certification after being modified, all in accordance with CSA Z7396.1 requirements.

3.11 Piping System Leakage Testing

- .1 Refer to Section entitled Basic Mechanical Materials and Methods. Ensure governing authorities are informed well in advance of scheduled tests so they may witness tests as required.

3.12 Power and Control Wiring

Medical Gas Piping Systems

- .1 Line voltage power wiring to equipment, unless otherwise specified, will be done as part of electrical work.
- .2 Control and alarm wiring, unless otherwise specified, is to be installed in conduit as part of medical gas system work in accordance with electrical work wiring requirements, and manufacturer's/supplier's certified wiring schematics.
- .3 Generally, power wiring (part of electrical work) and control and alarm wiring (part of mechanical work) is to be as follows:

EQUIPMENT	LINE VOLTAGE POWER WIRING	CONTROL AND/ OR ALARM WIRING
local alarm panels	115 volt to panel	
combo zone valve and area alarm units	115 volt to panel	

3.13 Equipment Start-Up and Certification

- .1 When installation of medical gas system equipment from source of supply up to but not including outlets is complete, and piping leakage testing is complete, but prior to certification as specified below, and in accordance with article entitled "Commissioning of Supply Systems" in CAN/CSA Z7396.1, arrange for equipment manufacturers/suppliers to visit site for length of time necessary to:
 - .1 check installation of equipment and recommend any adjustments required to be performed immediately;
 - .2 start-up equipment, test operation, recommend any adjustments required to be performed immediately, check and verify safeties, operational sequences, controls and alarms to ensure they are operating properly, and ensure equipment performs as intended;
 - .3 obtain letter(s) from system manufacturer(s)/supplier(s) certifying above requirements have been successfully completed, have letter(s) signed by system manufacturer(s)/supplier(s), and submit to Consultant.

3.14 Medical Gas System Certification

- .1 When equipment start-up and certification as specified above is complete, notify Owner and Consultant that systems are ready for certification in accordance with CAN/CSA Z7396.1.
- .2 Arrange for system installer to be part of certification team.
- .3 Should Owner's Certification Agency ("Agency") be delayed by your default or by the fact that you are not ready for certification procedure, or if scheduled certification is cancelled with less than 2 days' notice because systems are not ready, you will be responsible for all costs for the Agency to repeat tests, remain on site longer than could reasonably be expected, or reschedule tests, as applicable.

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- .4 Owner's Certification Agency will make interim site visits during construction to review medical gas system work. Cooperate with and reasonably assist the Agency, and immediately correct any deficient work reported by the Agency.

3.15 System Training

- .1 Include for 2 site training sessions for a minimum of 6 people for 8 hours per session. Training is to be a full review of all components including but not limited to a full operation and maintenance demonstration, with abnormal events.

END OF SECTION

HVAC Piping and Pumps

PART 1 - GENERAL

1.1 Submittals

- .1 Submit shop drawings/product data sheets for all products specified in this Section except piping and unions.
- .2 Submit motor product data sheets and certified performance curves with all pump shop drawings.
- .3 Submit with delivery of each unit a copy of factory inspection and test report, and include a copy of each report with O&M Manual project close-out data.
- .4 Submit a site inspection and start-up report from manufacturer's representative as specified in Part 3 of this Section.
- .5 Prior to Substantial Performance of the Work, submit a spare seal flush line filter for each pump equipped with a seal flush line.
- .6 Shop drawings for piping anchors must be prepared and stamped by a professional Structural Engineer registered in the jurisdiction of the work. Refer to requirements for Contractor retained engineers specified in Section entitled Mechanical Work General Instructions.
- .7 Submit a letter from pipe anchor design engineer to stating engineer has visited site to examine installation of pipe anchors and pipe anchor installation is in accordance with reviewed anchor shop drawing.

1.2 Quality Assurance

- .1 Pump motors are to comply with requirements of Section entitled Basic Mechanical Materials and Methods.

PART 2 - PRODUCTS

2.1 Pipe, Fittings and Joints

- .1 Black Steel - Screwed Joint
 - .1 Mild black carbon steel, Grade B, ASTM A53, complete with Class 125 cast iron threaded fittings to ANSI/ASME B16.4, and screwed joints.
 - .2 .
- .2 Black Steel - Grooved End Mechanical Joint
 - .1 Mild black carbon steel, Grade B, ASTM A53, factory or site roll grooved, complete with cast ductile iron grooved end fittings, including full flow elbows, and conforming to ASTM A536.
 - .2 Acceptable products are:

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- .1 Victaulic Style 107 "QuickVic" rigid couplings for sizes 50 mm (2") to 200 mm (8"), Style 07 "Zero-Flex" rigid couplings for sizes 250 mm (10") to 300 mm (12"), Style W07 AGS rigid couplings for sizes 350 mm (14") to 1525 mm (60");
- .2 Gruvlok Fig. 7402 "SlideLOK" for sizes 50 mm (2") to 200 mm (8"), Fig. 7401 "Rigidlok" for sizes 250 mm (10") to 610 mm (24").
- .3 Gaskets for Grooved End Mechanical Joints
 - .1 Unless otherwise noted, type Ethylene Propylene Diene Monomer (EPDM), suiting temperature and chemical compatibility for fluid used in intended applications.
 - .2 Confirm type with respective system manufacturers and review with Consultant.
- .4 Soft Copper Pipe
 - .1 Type "L" seamless soft copper to ASTM B77.
- .5 Hard Copper - Solder Joint
 - .1 Type "L" hard drawn seamless copper to ASTM B88, complete with wrought copper fittings to ANSI B16.22, and 95% tin / 5% Antimony solder joints.
- .6 Hard Copper - Pressure Coupled Joint
 - .1 Type "L" hard drawn seamless copper to ASTM B88, complete with Viega "ProPress with Smart Connect feature" system copper fittings with EPDM seals, and pressure type crimped joints made by use of manufacturer recommended tool.

2.2 Piping Unions

- .1 Screwed Piping
 - .1 Malleable iron, ground joint, bronze or brass to iron or bronze to bronze seat screwed unions and union elbows with a minimum pressure rating of 1725 kPa (250 psi) steam at 260°C (500°F).
- .2 Flanged Piping
 - .1 Forged carbon steel slip-on type raised faced welding flange unions to ASTM A105, 150 lb. Class for steel pipe, and slip-on type 150 lb. Class bronze flanges for copper pipe.

2.3 Shut-Off Valves

- .1 Ball Type
 - .1 Class 600, 4140 kPa (600 psi) WOG rated full port ball valves, each complete with a forged brass or bronze body and cap, blowout-proof stem, solid forged brass chrome plated ball, "Teflon" or "PTFE" seat, threaded ends, and removable lever handle.
 - .2 Acceptable products are:
 - .1 Toyo Valve Co. Fig. 5044A;
 - .2 Watts Industries (Canada) Inc. #FBV-3;

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- .3 Kitz Corp. Code 58;
- .4 Victaulic Co. of Canada Ltd. Series 722;
- .5 Apollo Valve #77-100.
- .2 Butterfly Type
 - .1 Cast ductile iron, lug body style, 1200 kPa (175 psi) rated butterfly valve, each complete with a neck to permit 50 mm (2") of insulation above the flange, a field replaceable EPDM seat, ductile iron disc, stainless steel shaft with EPDM seal, a lever handle for valves to and including 150 mm (6") diameter, a handwheel and gear type operator for valves larger than 150 mm (6") diameter, and each suitable for bubble-tight dead end service with valve closed and either side of connecting piping removed.
 - .2 Acceptable products are:
 - .1 DeZurik of Canada Ltd., Figure No. 632;
 - .2 Victaulic Co. of Canada Ltd. Vic-300 MasterSeal or AGS Vic-300;
 - .3 Apollo Valve 143 Series;
 - .4 Watts Industries (Canada) Inc. #BF-03;
 - .5 Kitz Corp. 6112 Series;
 - .6 Toyo Valve Co. 918DESL/G2.

2.4 Swing Check Valves

- .1 Bronze - Screwed
 - .1 Class 125, 1380 kPa (200 psi) WOG rated horizontal swing check valves, each complete with a "Y" pattern bronze body, hinged brass disc, easy access screw-in cap, and screwed ends.
 - .2 Acceptable products are:
 - .1 Toyo Valve Co. Fig. 236;
 - .2 Nibco #T-433;
 - .3 Kitz Corp. Code No. 22.
- .2 Steel - Grooved Ends
 - .1 Victaulic Co. of Canada Ltd. Series 716, 779 or W715 grooved end carbon steel check valves suitable for mounting horizontally or vertically.
- .3 Cast Iron - Screwed and Flanged
 - .1 Cast iron, bronze trim, 1380 kPa (200 psi) rated swing check valves, each complete with a bronze disc and seat, malleable iron hinge, bolted cover, and screwed or flanged ends as required.
 - .2 Acceptable products are:
 - .1 Toyo Valve Co. Fig. 435A;
 - .2 Watts Industries (Canada) Inc. #F-511;
 - .3 Kitz Corp. Code No. 78.

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2.5 Vertical Lift Check Valves

- .1 Class 150, 1380 kPa (200 psi) WOG rated bronze vertical lift check valves, each complete with screwed ends and a bronze disc.
- .2 Acceptable products are:
 - .1 Toyo Valve Co. Fig. 231;
 - .2 Watts Industries (Canada) Inc. #600;
 - .3 Kitz Corp. Code No. 36.

2.6 Wafer Check Valves

- .1 Threaded lug body type, full bore, ANSI Series 150, 1965 kPa (285 psi) rated at 38°C (100°F), non-slam wafer check valves, each complete with a carbon steel body, stainless steel discs, a shaft, springs, disc stop and thrust bearings constructed of type 316 stainless steel, and seat materials to suit the application. The inside diameter of the valve must equal the inside diameter of the connecting pipe.
- .2 Acceptable products are:
 - .1 Gulf Valve Co. "WAFER CHECK";
 - .2 Watts Industries (Canada) Inc. Series ICV-125;
 - .3 The Metraflex Co. Style CVXX.

2.7 Drain Valves

- .1 Minimum 2070 kPa (300 psi) WOG rated, 20 mm ($\frac{3}{4}$ ") diameter straight pattern bronze ball valves, each complete with a threaded outlet suitable for coupling connection of 20 mm ($\frac{3}{4}$ ") diameter hose, and a cap and chain.
- .2 Acceptable products are:
 - .1 Toyo Valve Co. Ltd. Fig. 5046;
 - .2 Watts Industries (Canada) Inc. #B-6000-CC;
 - .3 Kitz Corp. Code No. 68AC;
 - .4 Apollo Valves #78-104-01.

2.8 Circuit Balancing Valves

- .1 Screwed or flanged as required, globe style, non-ferrous circuit balancing valves designed to facilitate precise flow measurement, precision flow balancing, and positive shut-off, complete with capped and valved drain connection, and valved ports for connection to a differential pressure meter.
- .2 Acceptable products are:
 - .1 S.A. Armstrong Ltd. Series "CBVI" screwed or "CBVII" flanged;
 - .2 Victaulic Co. of Canada Ltd. (Tour & Anderson) Series 787 screwed, Series 788 flanged, and 789 grooved end, and Series 78K "Koil Kit" valves.

2.9 Pressure Relief Valves

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- .1 ASME tested, rated, and certified, bronze or cast iron bronze fitted, 1725 kPa (250 psi) rated pressure relief valves, each capable of relieving full output of equipment it is associated with, and each factory set at 415 kPa (60 psi) unless otherwise specified.
- .2 Acceptable products are:
 - .1 Xylem Bell & Gossett 3301/4100, or 790/1170;
 - .2 Dresser Industries "CONSOLIDATED";
 - .3 Spirax Sarco Ltd. SVI Series;
 - .4 McDonnell & Miller Models 250 and 260;
 - .5 Conbraco 10-600 Series;
 - .6 Watts Industries (Canada) Inc. 174A or 740.

2.10 Air Vents

- .1 Manual Air Vents
 - .1 Equal to Conbraco 27 Series, 3.2 mm ($\frac{1}{8}$ ") diameter with a key handle.
- .2 Automatic Air Vents
 - .1 Float actuated air vents, each complete with a semi-steel body and cap, a stainless steel float assembly and seat, and a neoprene head.
 - .2 Acceptable products are:
 - .1 Spirax Sarco Ltd., Type 13 W for system working pressures to 1035 kPa (150 psi), 13 WH for system working pressures greater than 1035 kPa (150 psi);
 - .2 Armstrong International Inc. No. 1-AV.

2.11 Strainers

- .1 Cast iron wye shaped strainers, minimum 890 kPa (125 psi) rated and complete with a removable type 304 stainless steel screen with perforations sized to suit the application, and, for strainers 50 mm (2") diameter and larger, a blowdown pipe connection tapping.
- .2 Acceptable products are:
 - .1 Spirax Sarco Ltd. Type IF-125 screwed or Type AF-250 flanged;
 - .2 Toyo Valve Co. Ltd. Fig. 380A screwed or Fig. 381 flanged;
 - .3 Victaulic Co. of Canada Style 732 or W732 "Vic-Strainer";
 - .4 Armstrong International Inc. A1 Series;
 - .5 Watts Industries (Canada) Inc. #77SCI;
 - .6 Mueller Steam Specialty Products Model 11M screwed or Model 758 flanged.

2.12 Piping Expansion Joints

- .1 Steel Piping Mains:

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- .1 Controlled flexing, flanged expansion joints, 2070 kPa (300 psi) rated, with corrugated stainless steel bellows with closely matched neck rings and reinforcing or control rings, and selected for operating pressure plus 25% safety factor.
- .2 Acceptable products are:
 - .1 Senior Flexonics Ltd. Series CSF "High-Corr";
 - .2 Victaulic Co. of Canada Ltd. Style 155 with Style 07 or 107 "Zero-Flex" couplings on each side of assembly and a full length steel "V" shaped support trough with hangers;
 - .3 The Metraflex Co. Model MC.
- .2 Steel or Copper Branch/Runout Piping:
 - .1 Externally pressurized, 1380 kPa (200 psi) rated expansion joints with a stainless steel bellows and shroud, welding or threaded steel nipple ends for steel piping, and copper sweat nipple ends for copper piping.
 - .2 Acceptable products are:
 - .1 Senior Flexonics Ltd. Series "H";
 - .2 The Metraflex Co. Model "HP".

2.13 Piping Alignment Guides

- .1 Prime coat painted black carbon steel pipe alignment guides sized and fabricated to suit pipe size and pipe insulation thickness.
- .2 Acceptable products are:
 - .1 Senior Flexonics Ltd. Series PGT;
 - .2 E. Myatt & Co. Ltd. Fig. 1267;
 - .3 Empire Tool & Mfg. Inc. Fig 256;
 - .4 The Metraflex Co. Style IV.

2.14 Pipe Anchors

- .1 Welded structural black steel anchors of a design, size, and type to securely anchor pipe at point shown. Each anchor is to withstand 150% of axial thrust, and, as specified in Part 1 of this Section, is to be designed and detailed by a Professional Structural Engineer.

2.15 Flexible Pump Connections

- .1 Flexible metal hose assemblies, each complete with annular corrugated unbraided type 321 stainless steel inner core, braided type 321 stainless steel hose, and a collar and flange at each end, all suitable for twice the working pressure of the system.
- .2 Acceptable products are:
 - .1 Senior Flexonics Inc. A1 and A6 Series;
 - .2 The Metraflex Co. Model SST and "METRA-MINI".

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2.16 Air Separator

- .1 Vortex type vertical air separator with side tangential inlet and outlet connections, a top air outlet connection, and bottom drain connection. Separator is to be constructed of cast iron or fabricated steel for a pressure of 1105 kPa (160 psi) at 180°C (350°F) in accordance with Section VIII, Division 1 of the ASME Boiler and Pressure Vessel Code.
- .2 Acceptable products are:
 - .1 S.A. Armstrong Ltd. Model "VA";
 - .2 Xylem Bell & Gossett "Rolairtrol";
 - .3 Taco Canada Ltd. "Vortech".

2.17 Expansion Tank

- .1 Replaceable bladder type, factory pressurized expansion tank with permanent separation of air and water, in accordance with drawing schedule and complete with:
 - .1 steel pressure tank suitable for a working pressure of 870 kPa (125 psi) at 115°C (240°F), constructed and stamped in accordance with the ASME Code for Unfired Pressure Vessels and complete with a system connection, drain connection, air charging valve, and a red oxide primer finish;
 - .2 heavy-duty butyl rubber (EDPM) bladder;
 - .3 tapping for installation of a pressure gauge;
 - .4 for horizontal tanks, mounting saddles supplied loose;
 - .5 factory secured seismic restraint connection hardware.

2.18 Glycol Solution Mixing and Storage Tank

- .1 Package type glycol solution mixing, storage and automatic feed assembly designed to maintain minimum system pressure levels and complete with:
 - .1 round, polyethylene or polypropylene tank sized to suit system capacity, complete with a solution level scale in litres and Imperial gallons, removable cover, and a welded steel angle stand assembly with legs, pump shelf, and control panel bracket, all factory finished with enamel;
 - .2 120 volt, 1-phase, 60 Hz electrical connection;
 - .3 factory pre-piped rotary bronze gear pump with capacity and pressure differential to suit system requirements, factory wired to control panel, mounted on a shelf integral with steel stand assembly, and complete with shut-off valve and strainer;
 - .4 tank pressure relief valve with discharge piped back into tank;
 - .5 tank low level switch;
 - .6 pressure gauge;
 - .7 Honeywell #L404A "Pressurtrol" or equal pipe mounting differential pressure switch with a 100 to 1000 kPa (15 to 150 psi) range;

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- .8 factory mounted and pre-wired control panel with a minimum NEMA 2 enamelled steel enclosure, designed to control and operate pump either manually or automatically to pump glycol solution into system, and to stop pump and initiate an audible/visual alarm if a low glycol solution level occurs in tank, and complete with:
 - .1 terminal blocks for power and control wiring connections;
 - .2 H-O-A switch with green "Power On" indicator light;
 - .3 120 volt/12 volt control transformer;
 - .4 low glycol solution level alarm buzzer with silencing switch, an alarm light which remains illuminated until low-level switch is reset, and an alarm push-to-test button;
 - .5 dry contacts for building automation system alarm annunciation.
- .9 factory secured seismic restraint connection hardware.

2.19 Glycol

- .1 Propylene glycol blended with Nitrite based corrosion inhibitors.

2.20 General Re: Circulating Pumps

- .1 Pumps are to be bronze fitted centrifugal pumps in accordance with drawing schedule, each non-overloading under all operating conditions and factory tested at specified operating conditions.

2.21 Base Mounted Pumps

- .1 End suction, horizontal, top discharge, factory mounted and aligned on a steel baseplate, connected to a motor by means of a flexible coupling with guard, and complete with:
 - .1 heavy-duty, radially split, gasketed cast iron volute designed for servicing and removal of rotating assembly without disturbing pipe connections, and complete with plugged tappings for gauge and drain;
 - .2 balanced bronze impeller secured to a carbon steel shaft equipped with a stainless steel shaft sleeve;
 - .3 ball type, heavy-duty, lifetime lubricated sealed bearings with back pull-out design bearing frame;
 - .4 TEFC motor;
 - .5 watertight John Crane Inc. JC2, OPID1 carbon rotating face type mechanical seal with tungsten carbide stationary seat, Viton secondary seal and alloy 20 springs, and bronze gland plate with stainless steel gland bolts to secure the stationary seat.
- .2 Acceptable manufacturers are:
 - .1 S.A. Armstrong Ltd.;
 - .2 Xylem Bell & Gossett;
 - .3 Grundfos CBS Inc. PACO;

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- .4 Patterson Pump Company.

2.22 Split Coupled Vertical In-Line Pump

- .1 Split coupled, single stage, vertical in-line pump complete with:
 - .1 radially split, gasketed cast iron volute with equally sized suction and discharge flanged connections, tappings for gauge, drain and flush line connections, and a cast iron motor mount bracket;
 - .2 dynamically balanced cast bronze impeller secured to a type 416 stainless steel shaft which is connected to motor by means of a high tensile strength aluminium bar split type spacer coupling with guard designed to permit servicing of mechanical seal without disturbing pump, motor, or electrical wiring;
 - .3 TEFC vertical mount motor;
 - .4 watertight John Crane Inc. #JC8B2, XP1D1 or Durametallic #RA EU5-FV carbon rotating face type outside mechanical seal with tungsten carbide stationary seat, Viton secondary seal and alloy 20 springs, and bronze gland plate with stainless steel gland bolts to secure stationary seat;
 - .5 factory installed seal flush line tubing with 50 micron Cuno cartridge type filter with 2 extra cartridges, a sight flow indicator, air vent, and valved tubing;
 - .6 for pump(s)____, in lieu of a flush line filter, factory installed valved seal flush line tubing with cyclone type separator and sight flow indicator.
- .2 Acceptable manufacturers are:
 - .1 S.A. Armstrong Ltd.;
 - .2 Xylem Bell & Gossett;
 - .3 Grundfos CBS Inc. PACO;
 - .4 Patterson Pump Company.

2.23 Close Coupled Vertical In-Line Pump

- .1 Close coupled, single stage vertical in-line pump complete with:
 - .1 radially split, gasketed cast iron volute with equally sized suction and discharge flanged connections, and tappings for gauge, drain and flush line connections;
 - .2 dynamically balanced bronze impeller with bronze shaft sleeve, secured to motor shaft;
 - .3 face mounted TEFC vertical motor;
 - .4 watertight John Crane Inc. #JC 8B2, XP1D1 or Durmetallic #RA EU5-FV carbon rotating face type inside mechanical seal with tungsten carbide stationary seat, Viton secondary seal and alloy 20 springs, and bronze gland plate with stainless steel gland bolts to secure stationary seat.
- .2 Acceptable manufacturers are:
 - .1 S.A. Armstrong Ltd.;
 - .2 Xylem Bell & Gossett;
 - .3 Grundfos CBS Inc. PACO;

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- .4 Patterson Pump Company.

2.24 Split Coupled, Dual Vertical In-Line Pump

- .1 Split coupled, single stage, vertical in-line pump assemblies incorporating 2 radially split pumps, complete with:
 - .1 cast iron volute with equally sized suction and discharge flanged connections, tappings for gauge, drain and flush line connections, and cast iron motor mount brackets;
 - .2 for each pump, dynamically balanced cast bronze impeller secured to a type 416 stainless steel shaft which is connected to motor by means of a high tensile strength aluminium bar split type spacer coupling with guard designed to permit servicing of mechanical seal without disturbing pump, motor, or electrical wiring;
 - .3 for each pump, a TEFC vertical mount motor;
 - .4 for each pump, a watertight John Crane Inc. #JC8B2, XP1D1 or Durametallic #RA EU5-FV carbon rotating face type outside mechanical seal with tungsten carbide stationary seat, Viton secondary seal and alloy 20 springs, and bronze gland plate with stainless steel gland bolts to secure the stationary seat;
 - .5 factory installed seal flush line tubing with 50 micron Cuno cartridge type filter with 2 extra cartridges, a sight flow indicator, air vent, and valved tubing;
 - .6 for pump(s) ____, in lieu of a flush line filter, factory installed valved seal flush line tubing with cyclone type separator and sight flow indicator.
- .2 Acceptable manufacturers are:
 - .1 S. A. Armstrong Ltd.;
 - .2 Xylem Bell & Gossett;
 - .3 Grundfos CBS Inc. PACO.

2.25 Split Coupled, Dual, VFD Drive Vertical In-Line Pump

- .1 Split coupled, single stage, vertical in-line pump assemblies incorporating 2 radially split pumps, complete with:
 - .1 cast iron volute with equally sized suction and discharge flanged connections, tappings for gauge, drain and flush line connections, and cast iron motor mount brackets;
 - .2 for each pump, a dynamically balanced cast bronze impeller secured to a type 416 stainless steel shaft which is connected to motor by means of a high tensile strength aluminium bar split type spacer coupling with guard designed to permit servicing of mechanical seal without disturbing pump, motor, or electrical wiring;
 - .3 for each pump, a TEFC vertical mount motor;
 - .4 for each pump, a watertight John Crane Inc. #JC8B2, XP1D1 or Durametallic #RA EU5-FV carbon rotating face type outside mechanical seal with tungsten carbide stationary seat, Viton secondary seal and alloy 20 springs, and bronze gland plate with stainless steel gland bolts to secure stationary seat;

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- .5 factory installed seal flush line tubing with 50 micron Cuno cartridge type filter with 2 extra cartridges, a sight flow indicator, air vent, and valved tubing;
- .6 for each pump, a factory mounted VFD pre-wired to pump motor, capable of operating in any of following control modes:
 - .1 duty/standby pumps with sensorless control;
 - .2 duty/standby pumps with remote sensor or building automation system control;
 - .3 parallel pumps with single or multiple sensor(s) system control with IPS controller.
- .7 for pump(s)____, in lieu of a flush line filter, factory installed valved seal flush line tubing with cyclone type separator and sight flow indicator.
- .2 Acceptable manufacturers are:
 - .1 S. A. Armstrong Ltd.;
 - .2 Xylem Bell & Gossett;
 - .3 Grundfos CBS Inc. PACO.

2.26 Close Coupled, Dual Vertical In-Line Pump

- .1 Close coupled, single stage, vertical in-line pump assemblies incorporating 2 radially split pumps, complete with:
 - .1 cast iron volute with equally sized suction and discharge flanged connections, tappings for gauge, drain and flush line connections, and cast iron motor mount brackets;
 - .2 for each pump, a dynamically balanced cast bronze impeller secured to a type 416 stainless steel shaft which is connected to motor by means of a high tensile strength aluminium bar split type spacer coupling with guard designed to permit servicing of mechanical seal without disturbing pump, motor, or electrical wiring;
 - .3 for each pump, a TEFC vertical mount motor;
 - .4 for each pump, a watertight John Crane Inc. #JC8B2, XP1D1 or Durametallic #RA EU5-FV carbon rotating face type outside mechanical seal with tungsten carbide stationary seat, Viton secondary seal and alloy 20 springs, and bronze gland plate with stainless steel gland bolts to secure stationary seat;
 - .5 factory installed seal flush line tubing with 50 micron Cuno cartridge type filter with 2 extra cartridges, a sight flow indicator, air vent, and valved tubing;
 - .6 for pump(s)____, in lieu of a flush line filter, factory installed valved seal flush line tubing with cyclone type separator and sight flow indicator.

2.27 Vertical In-Line Pump Variable Frequency Drives

- .1 Variable frequency drives for vertical in-line pumps as scheduled are to be in accordance with Section entitled Variable Frequency Drives.

2.28 Circulating Pump Suction And Discharge Connection Accessories

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- .1 Circulating pump manufacturer supplied suction guides with a cast iron body, stainless steel strainer screen, removable fine mesh start-up strainer screen and steel guide vanes, and cast iron body, angle, or straight type control valve assemblies, each acting as a check valve, balancing valve, and shut-off valve. Unless otherwise shown or specified, suction and discharge connection accessories are to be piping line size.
- .2 Acceptable products are:
 - .1 S.A. Armstrong Ltd. Type "SG" suction guides and "Flo-Trex" triple duty valve assemblies;
 - .2 Xylem Bell & Gossett Bulletin B-820D suction guides and Bulletin B-821F triple duty valve assemblies.

2.29 Horizontal In-Line Pump

- .1 Horizontal, in-line pump complete with:
 - .1 cast iron casing with flanged in-line pipe connections;
 - .2 alloy steel shaft with integral thrust collar, copper shaft sleeve, and oil lubricated bronze bearings;
 - .3 balanced, corrosion resistant steel, cast bronze, or stamped brass impeller;
 - .4 motor connected to pump by means of a 4-spring coupling with guard;
 - .5 mechanical seal.
- .2 Acceptable manufacturers are:
 - .1 S.A. Armstrong Ltd.;
 - .2 Xylem Bell & Gossett;
 - .3 Grundfos Canada Inc.

2.30 Wet Rotor 3-Speed Horizontal In-Line Pump

- .1 Grundfos Canada Inc. "VersFlo" Series UPS wet rotor design, 3-speed horizontal in-line pump with a head-capacity curve that has a steady rise in head from maximum to minimum flow within preferred operating range, factory tested as an assembly and with a maximum noise level when operating of 41 dBA, capable of continuous operation at 120°C (248°F), and equipped with:
 - .1 cast iron housing with flanged inlet and outlet with gauge taps, laser welded stainless steel impeller, bearing plate and shaft, stainless steel neck ring, dynamically balanced rotor with stainless steel cladding, and tungsten carbide sleeve type motor bearings;
 - .2 3-speed asynchronous, squirrel cage, self-venting motor cooled by pumped fluid and complete with stator housing drain holes to permit condensed water to drain;
 - .3 bolt-on terminal box with 3-speed switch assembly with each speed having a distinct pump performance curve, and fibre optic indicator lights for visual inspection of on/off, rotation, and troubleshooting;
 - .4 terminal box add-on protective module to permit direct electrical connection to feeder switch;

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- .5 terminal box add-on relay module to permit direct connection to electrical feeder switch, signals output for external operating or fault indications, and to permit operation of 2 pumps in parallel with 24 hour alternation;
- .2 Acceptable manufacturers are:
 - .1 Grundfos Canada Inc.;
 - .2 S. A. Armstrong Ltd.

2.31 Wet Rotor Variable Speed Horizontal In-Line Pump

- .1 Grundfos Canada Inc. "Magna" Series wet rotor design, horizontal, variable frequency drive in-line pump with a head-capacity curve that has a steady rise in head from maximum to minimum flow within preferred operating range, factory tested as an assembly and with a maximum noise level when operating of 41 dBA, capable of continuous operation at 120°C (248°F), and equipped with:
 - .1 cast iron housing with flanged inlet and outlet with gauge taps, laser welded stainless steel impeller, bearing plate and shaft, stainless steel neck ring, dynamically balanced rotor with stainless steel cladding, and tungsten carbide sleeve type motor bearings;
 - .2 squirrel cage, self-venting motor suitable for a VFD, cooled by pumped fluid and complete with stator housing drain holes to permit condensed water to drain;
 - .3 bolt-on, integrated, CSA or ETL certified variable frequency drive assembly with "AUTOADAPT" function which automatically adjusts proportional pressure and sets an efficient performance curve whenever possible, an operating panel with control modules and clear indications for pump flow rate and head, and a bus communication module for site connection into building automation system.
- .2 Acceptable manufacturers are:
 - .1 Grundfos Canada Inc. "Magna" Series;
 - .2 Taco Canada Ltd. "Delta T".

PART 3 - EXECUTION

3.1 Demolition

- .1 Perform required hydronic piping system demolition/revision work. Refer to demolition requirements specified in Section entitled Demolition and Revision Work.

3.2 Piping Installation Requirements

- .1 Provide required hydronic piping. Pipe, unless otherwise specified, is to be:
 - .1 for pipe to and including 65 mm (2-½") diameter, Schedule 40 black steel, screwed, or type "L" hard copper with solder joints or pressure coupled joints;
 - .2 for pipe 65 mm (2-½") to 300 mm (12") dia. and larger, Standard weight grooved end black steel (10 mm [0.375"] thickness) pipe with grooved end fittings and couplings, or, Standard weight black steel (10 mm [0.375"] thickness) pipe with welding fittings and welded joints;

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- .3 for short branch connections to heating equipment where structural obstructions occur and site bending of pipe is advantageous, a single length of type "L" soft copper.
- .2 Slope horizontal piping mains to provide a minimum continuous up-grade of 25 mm (1") in 6 m (20') to high points. Slope branch supply and return piping connections to equipment a minimum of 25 mm (1") in 1.2 m (4'). Leave sufficient room at high points for installation and maintenance of air vents.
- .3 Install automatic control valves, piping wells and similar piping and/or equipment mounted control components required for automatic temperature control systems supplied as part of the control work. Refer to drawing control diagrams and details.
- .4 Connect equipment provided as part of the work of other Sections with piping as indicated and/or required. Refer to pipe connection details on drawings.
- .5 Provide screwed unions, removable mechanical joint couplings, or weld-on or solder-on flanges in piping at all connections to valves, strainers and similar piping system components which may need maintenance or repair, at equipment connections, in runs of piping exceeding 9 m (30') at 4.5 m (15') regular intervals to permit removal of sections of piping, and wherever else indicated on drawings.
- .6 Provide shut-off valves in piping connections to equipment, to isolate piping risers, to isolate other sections of systems as shown, and wherever else indicated on drawings. Valves in piping to and including 50 mm (2") dia. are to be ball type. All other shut-off valves are to be ball or butterfly type unless otherwise specified. Locate valves so they are easily accessible. Wherever possible, install valves at uniform height. Provide chain operators for valves which are inaccessible for operation from floor level.
- .7 Provide a check valve in discharge piping of every pump, and elsewhere in piping where shown on drawings. Where check valves are required in vertical piping, ensure they are suitable in all respects for the application. Check valves for vertical in-line and/or base mounted circulating pumps are integral with the discharge accessory.
- .8 Provide a drain valve at base of each piping riser, in drain connections to equipment, in low points of horizontal piping, and wherever else shown and/or specified.
- .9 Provide circuit balancing valves in piping generally where shown on drawings but with exact locations in accordance with instructions of personnel doing system flow balancing work. Confirm locations prior to installation.

3.3 Installation of Pressure Relief Valves

- .1 Provide factory set pressure relief valves. Pipe discharge of each water piping relief valve to drain unless otherwise shown or specified.
- .2 Pipe discharge of each glycol solution piping relief valve back to system expansion tank or return piping.
- .3 Confirm relief valve settings.

3.4 Installation of Air Vents

- .1 Provide an air vent in piping mains at all high points, at equipment connections, and wherever else shown and/or specified. Equip each air vent with a ball type shut-off valve. Install vents in 100 mm (4") dia. and larger piping and all vents in mechanical rooms in accordance with drawing detail.

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- .2 Provide 9 mm (3/8") dia. copper drain piping from each automatic air vent to nearest suitable drain and terminate so discharge is visible. Identify drain piping.

3.5 Installation of Strainers

- .1 Provide strainers in piping. Locate strainers so baskets are easily accessible and removable. Clean strainer baskets during and after piping system flushing and cleaning is complete, and before water quantity balancing commences.

3.6 Installation of Expansion Compensators

- .1 Provide expansion compensation in piping.
- .2 Generally, locate expansion compensation where shown, but with exact locations to suit piping as installed.
- .3 Provide double pipe alignment guides in horizontal piping at each side of expansion compensation facilities to permit movement in axial direction only. Secure guides to building structure only.
- .4 Provide a pipe guide at each side of expansion joints in vertical risers.

3.7 Installation of Piping Anchors

- .1 Provide anchors to secure piping to structure. Locate anchors generally where shown but with exact locations to suit piping as installed and requirements of reviewed anchor shop drawings.
- .2 When installation of anchors is complete, arrange, and pay for anchor design engineer to visit site to review anchor installation. Submit a signed letter with engineer's stamp from design engineer confirming each anchor is properly installed.

3.8 Installation of Air Separator

- .1 Provide an air separator in piping and connect with valved inlet and outlet piping.
- .2 Extend valved blowdown piping from bottom pipe connection tapping to nearest floor drain location.
- .3 Equip top pipe connection tapping with an automatic air vent, and piping as detailed.

3.9 Installation of Expansion Tank

- .1 Provide an expansion tank.
- .2 Secure horizontal expansion tank in place from structure by means of properly sized galvanized steel hanger rods and support saddles supplied with tank.
- .3 Secure tank stand to a concrete housekeeping pad by means of machine bolts.
- .4 Provide a water make-up connection line complete with relief valve and pressure gauge and connect to system piping. Terminate make-up piping for connection to domestic cold water piping as part of the work of Section entitled Domestic Water Piping and Valves. Check relief valve operation and adjust as required.
- .5 Check tank air charge and adjust to suit system.
- .6 Brace and secure tank in accordance with requirements specified in Section entitled Seismic Control and Restraint

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- .7 Connect tank with system piping. Extend a drain line from tank piping and terminate drain line with a drain valve. Provide an air vent.

3.10 Installation of Glycol Solution Mixing and Storage Tank

- .1 Provide a mixing and storage tank and feed assembly for each glycol solution circulating system.
- .2 Secure tank stand to a concrete housekeeping pad. Connect with system piping. Refer to drawing detail.
- .3 Brace and secure each unit in accordance with requirements specified in Section entitled Seismic Control and Restraint.
- .4 Fill tank with, unless otherwise specified, a solution of 50% water, 50% propylene glycol, and test solution to confirm proper concentrations.
- .5 When installation is complete, test operation of assembly, including alarms, and adjust as required. Adjust pressure switch to suit glycol solution circulating system pressure.

3.11 Installation of Flexible Piping Connections

- .1 Provide flexible connections in piping connections to equipment.
- .2 Install in accordance with manufacturer's instructions.

3.12 Installation of Circulating Pumps

- .1 Provide centrifugal circulating pumps.
- .2 Provide a shut-off valve and suction guide in pump suction piping, and a combination check-balance-shut-off valve assembly in pump discharge piping, installed in accordance with manufacturer's instructions. Remove suction guide start-up strainer screens after piping flushing and cleaning is complete. Combination check-balance-shut-off valve assemblies are to be 150 mm (6") away from pump discharge for discharge piping to 150 mm (6") dia., and 300 mm (12") away from pump discharge for discharge pipe larger than 150 mm (6") dia.
- .3 For pumps equipped with seal flush line filters, replace flush line filter cartridge when pipe flushing and cleaning is complete, and hand identified spare filter cartridges to Owner at site.
- .4 Supply variable frequency drives (VFD) for pumps as scheduled. Hand VFD's to electrical trade at site for installation as part of the electrical work.
- .5 Install horizontal inline pumps in place in vertical piping approximately 1.2 m (4') above floor in accordance with pump manufacturer's instructions.
- .6 If circulating pumps are used for piping flushing and cleaning, and pump seal flush line filters are not installed, replace pump mechanical seals when flushing and cleaning is complete.
- .7 Refer to Section entitled Basic Mechanical Materials and Methods for equipment/system manufacturer certification requirements.
- .8 Refer to Section entitled Basic Mechanical Materials and Methods for equipment/system start-up requirements.

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- .9 Include for a 1/2 day on-site operation demonstration and training session. Training is to be a full review of all components including but not limited to a full operation and maintenance demonstration, with abnormal events.
- .10 Secure base mounted pumps in place on seismic rated structural steel bases with vibration isolators as specified in Section entitled Mechanical Vibration Control, and restrain as specified in Section entitled Seismic Control and Restraint. Provide flexible connectors in pump suction and discharge piping 450 mm (18") from suction and discharge connection accessories.
- .11 Secure base mounted pumps in place on a concrete housekeeping pad. Shim pump baseplate level using metal wedges prior to tightening bolts. When installation is complete and pump-motor alignment has been checked, fill void between pump base and housekeeping pad with KPM Industries Ltd. "In-Pakt" or equal non-shrink grout. Provide flexible connections in pump suction and discharge piping 450 mm (18") from suction and discharge connection accessories.
- .12 Floor mount vertical inline pumps with seismically rated neoprene vibration isolators as specified in Section entitled Mechanical Vibration Control, and seismically rated steel pump mounting brackets custom welded to suction and discharge connections of pump. Refer to Section entitled Seismic Control and Restraint for further mounting requirements. Provide flexible connectors in vertical suction and discharge piping 450 mm (18") above suction and discharge connection accessories.
- .13 Secure vertical inline pumps in place in accordance with requirements of drawing detail and provide flexible piping connections in vertical suction and discharge piping approximately 450 mm (18") above suction and discharge connection accessories.
- .14

3.13 Flushing and Cleaning Piping

- .1 Flush and clean new piping in accordance with requirements specified in Section entitled HVAC Water Treatment.

3.14 Testing, Adjusting and Balancing

- .1 When work is complete and equipment is operating as intended, test, adjust and balance water flows in accordance with requirements specified in Section entitled Testing, Adjusting, and Balancing.

END OF SECTION

PART 1 - GENERAL

1.1 Submittals

- .1 Submit shop drawings/product data sheets for all products specified in this Section except shop fabricated ductwork and fittings.
- .2 Include capacity, throw and terminal velocity, noise criteria, and pressure drops with grille and diffuser shop drawing/product data sheet submission.
- .3 Submit duct leakage test data prior to ductwork being covered from view.
- .4 Supply and hand to Owner at Substantial Performance of the Work, a minimum of 10 identified (with tags) grille/diffuser volume control damper adjustment keys.

1.2 Quality Assurance

- .1 Grilles and diffusers are to be tested and performance certified to ANSI/ASHRAE 70, Method of Testing the Performance of Air Outlets and Air Inlets.

PART 2 - PRODUCTS

2.1 Galvanized Steel Ductwork

- .1 Galvanized steel sheet is to be hot dipped in accordance with requirements of ASTM A653. Provide G60 galvanizing for bare uncovered duct and with finish paint. Provide G90 galvanizing for other galvanizing.
- .2 Rectangular
 - .1 Lock forming grade hot dip galvanized steel, ASTM A653, shop fabricated, minimum #26 gauge.
- .3 Round
 - .1 Factory machine fabricated, spiral, mechanically locked flat seam, single wall duct, fittings and couplings.
- .4 Flat Oval
 - .1 Factory machine fabricated, single wall, 4-ply spiral lock seam duct, fittings and couplings.

2.2 Flexible Metallic Ductwork

- .1 Bare
 - .1 Spirally wound, semi-rigid, self-supporting corrugated aluminum duct with continuous triple lock seams, SMACNA Form "M-UN", ULC S110 listed and labelled as a Class 1 Air Duct, constructed of dead soft aluminum strip, and supplied in 3 m (10') lengths.
- .2 Insulated

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- .1 Spirally wound, semi-rigid, self-supporting corrugated aluminum duct with continuous triple lock seams, SMACNA Form "M-I", ULC S110 listed and labelled as a Class 1 Air Duct, constructed of dead soft aluminum strip, supplied in 3 m (10') lengths and factory covered with 40 mm (1-1/2") thick, 12 kg/m³ (0.75 lb/ft³) density fibreglass insulation with a vinyl jacket meeting 25/50 flame spread and smoke developed requirements tested in accordance with CAN/ULC S102.

2.3 Flexible Connection Material

- .1 Waterproof, indoor-outdoor type flexible connection material meeting requirements of NFPA 90A, consisting of woven glass fibre fabric coated on both sides with synthetic rubber. Acceptable products are:
 - .1 Duro Dyne Canada Inc. "DUROLON";
 - .2 Dyn Air Inc. "HYPALON".

2.4 Metal Duct System Joint Sealant

- .1 ULC listed and labelled, premium grade, grey colour, water base, non-flammable duct sealer, brush, or gun applied, with a CAN/ULC S102 tested maximum flame spread rating of 5 and smoke developed rating of 0.
- .2 Acceptable manufacturers are:
 - .1 Duro Dyne Canada Inc.
 - .2 Ductmate Industries.
 - .3 H.B. Fuller Company (Foster).

2.5 Round to Rectangular Duct Connections

- .1 Equal to Flexmaster Canada Ltd. galvanized steel, flared, flanged or notched "Spin-On" round duct take-off collars with locking dampers in accordance with ANSI/SMACNA HVAC Duct Construction Standards Metal and Flexible.

2.6 Splitter Dampers

- .1 Minimum #20 gauge damper blade constructed of same material as duct, reinforced as required to suit blade size, system velocity, and to prevent "chatter", and complete with operating hardware equal to DynAir Inc. #Q-50 "DYN-A-QUAD S-S" quadrant regulator with RW-50 backup washers to prevent leakage, long square bearing pin, and slide pin.

2.7 Air Turning Vanes

- .1 For square elbows, multiple-radius turning vanes interconnected with bars, adequately reinforced to suit pressure and velocity of system, constructed of same material as duct they are associated with, and in accordance with ANSI/SMACNA HVAC Duct Construction Standards Metal and Flexible.
- .2 For short branch ducts at grille and diffuser connections, air extractor type each equipped with a matching bottom operated 90° opposed blade volume control damper, constructed of same material as duct it is associated with and in accordance with requirements and details in ANSI/SMACNA HVAC Duct Construction Standards Metal and Flexible.

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2.8 Manual Balancing (Volume) Dampers

- .1 Flanged and drilled, single or parallel blade (depending on damper size) manual balancing dampers, each constructed of same material as connecting ductwork unless otherwise specified, each designed to maintain internal free area of connecting duct, and each complete with:
 - .1 hexagonal or square shaft extension through frame;
 - .2 non-stick, non-corrosive synthetic bearings for rectangular dampers, flange stainless steel bearings for round dampers;
 - .3 blade stops for single blade dampers, designed to prevent blade from moving more than 90°;
 - .4 linkage for multiple blade dampers;
 - .5 locking hand quadrant damper operator with 50 mm (2") standoff mounting for insulated ducts.
- .2 Rectangular Dampers: Nailor Industries Inc. 1800 Series, maximum size 1.2 m x 1.2 m (4' x 4') for a single damper.
- .3 Round Dampers: Nailor Industries Inc. Model 1890, maximum 600 mm (24") diameter, equipped with a minimum 200 mm (8") deep frame, and blade stiffeners where required.
- .4 Multiple Rectangular Damper Section Assembly: Rectangular assembly supplied with the dampers or site constructed, of same material as damper and designed for tight and secure mounting of individual dampers.
- .5 Acceptable manufacturers are:
 - .1 Nailor Industries Inc.;
 - .2 T.A. Morrison & Co. Inc. "TAMCO";
 - .3 NCA Manufacturing Ltd.;
 - .4 Greenheck Fan Corp.;
 - .5 Ruskin Co.
 - .6 Pottorff.

2.9 Backdraft Dampers

- .1 Nailor Industries Model 1370CB counterbalanced backdraft dampers, vertical or horizontal mounting, 50 mm (2") wide, sized as shown and complete with:
 - .1 extruded 6063-T5 aluminum frame, 2.3 mm (0.090") nominal wall thickness, with mitred corners;
 - .2 extruded 6063-T5 aluminum blades, 1.3 mm (0.050") nominal wall thickness on 92 mm (3-5/8") centres, and with extruded PVC blade seals;
 - .3 corrosion-resistant synthetic bearings;
 - .4 adjustable plated steel counterweights mounted internally in the airstream;
 - .5 concealed blade linkage located out of the airstream.
- .2 Acceptable manufacturers are:

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- .1 Nailor Industries Inc.;
- .2 T.A. Morrison & Co. Inc. "TAMCO";
- .3 NCA Manufacturing Ltd.;
- .4 Greenheck Fan Corp.;
- .5 Ruskin Co.
- .6 Pottorff.

2.10 Fusible Link Dampers

- .1 Curtain blade type, dynamic, galvanized steel (unless otherwise specified) fusible link dampers, ULC classified to CAN/ULC S112 and in accordance with NFPA 90A requirements, factory tested for closure under airflow, 1-1/2 hour or 3 hour rated as required, and complete with a constant force type 301 stainless steel closure spring, a blade lock assembly, a steel sleeve, retaining angles, and, unless otherwise specified, a 74°C (165°F) rated standard fusible link.
- .2 Fusible link dampers are to be Type "B" or Type "C" (as required) with folded curtain blade out of air stream except where damper size or location requires use of type "A" dampers with curtain blade in air stream.
- .3 Acceptable manufacturers are:
 - .1 Nailor Industries Inc.;
 - .2 Greenheck Fan Corp.;
 - .3 NCA Manufacturing Ltd.;
 - .4 Ruskin Co.;
 - .5 Price Industries (E.H. Price).
 - .6 Pottorff.

2.11 Combination Fire/Smoke Dampers

- .1 Nailor Industries Series 1220, ULC listed to CAN/ULC S112 and CAN/ULC S112.1, meeting requirements of NFPA 80, 90A, 92, 101 and 105, consisting of type A, B, or C fusible link fire dampers as required and a fail-safe, opposed blade, normally closed, motor operated smoke damper complete with factory installed and tested 120 V electric actuator.
- .2 ULC 1-1/2 hour fire rated and ULC Class I leakage rated for smoke, and equipped with a 74°C (165°F) ULC classified fusible link that will cause damper to close and lock independent of actuator when duct temperature reaches maximum temperature of damper assembly.
- .3 Supply damper with factory installed sleeves of minimum 400 mm (16") length, field verified by contractor dependent on wall thickness. Caulk sleeves to ULC requirements and constructed of 20 gauge for sizes up to 2.1 m (84") wide and 18 gauge for sizes greater than 2.1 m (84") wide.
- .4 Acceptable manufacturers are:
 - .1 Nailor Industries Inc.;

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- .2 Greenheck Fan Corp.;
- .3 NCA Manufacturing Ltd.;
- .4 Ruskin Co.;
- .5 Price Industries (E.H. Price).
- .6 Pottorff.

2.12 Smoke Dampers

- .1 Multi-blade type, fail-safe, dynamic, galvanized steel (unless otherwise specified) smoke dampers, ULC classified to CAN/ULC S112.1, ULC Class I leakage rated for smoke, meeting requirements of NFPA 90A, 92, 101 and 105, normally closed, low pressure drop design, dynamically tested, each complete with jamb and blade seals, linkage concealed in the frame, a steel sleeve to suit the opening, and an electric actuator to automatically close damper upon receiving an external signal, and to automatically open damper when system is reset.
- .2 Acceptable manufacturers are:
 - .1 Nailor Industries Inc.;
 - .2 Greenheck Fan Corp.;
 - .3 NCA Manufacturing Ltd.;
 - .4 Ruskin Co.;
 - .5 Price Industries (E.H Price).
 - .6 Pottorff.

2.13 Duct Access Doors

- .1 In accordance with ANSI/SMACNA HVAC Duct Construction Standards Metal and Flexible, with sizes suitable in all respects for purpose for which they are provided, and, unless otherwise specified, constructed of same material as duct they are associated with.

2.14 Ductwork Drain Points

- .1 Equal to Ductmate Canada Ltd. "Moisture Drain", 20 mm ($\frac{3}{4}$ ") diameter moisture drains with galvanized sheet metal funnel, and chrome plated brass threaded drain, nut and cap.

2.15 Instrument Test Ports

- .1 Equal to Duro-Dyne of Canada Ltd. #IP1 or #IP2 (to suit insulation thickness where applicable) gasketed, leakproof instrument test ports for round or rectangular ducts as required, each complete with a neoprene expansion plug and a plug securing chain.

2.16 Wire Mesh (Birdscreen)

- .1 Heavy-gauge galvanized steel or aluminum mesh, 12 mm x 12 mm ($\frac{1}{2}$ " x $\frac{1}{2}$ ") secured in a rigid galvanized steel or aluminum framework, sized as indicated on drawings, and constructed so as to be removable.

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2.17 Louvres

- .1 Price Industries Inc. DE439 or DE635, 100 mm (4") or 150 mm (6") deep (to suit wall thickness) factory assembled stationary, drainable, storm-proof louvres sized as indicated on drawings, each AMCA water penetration and air performance certified, constructed of welded, extruded, alloy 6063-T5 aluminum with drainable blades, mounting and securing hardware to suit the application, and 12 mm (½") mesh aluminum birdscreen in an aluminum frame.
- .2 Louvres are to be factory finished with a finish equal to PPG Industries "Duramar" fluoropolymer powder coating over primer with colour as selected from manufacturer's standard colour range.
- .3 Acceptable manufacturers are:
 - .1 Price Industries Inc.;
 - .2 The Airolite Co. LLC;
 - .3 Construction Specialities;
 - .4 Nailor Industries Inc.;
 - .5 Greenheck Fan Corp.
 - .6 Pottorff.

2.18 Grilles and Diffusers

- .1 Grilles and diffusers of type, size, capacity, finish, and arrangement as shown on drawings and in accordance with drawing schedule, each equipped with all required mounting and connection accessories to suit mounting location and application.
- .2 Acceptable manufacturers are:
 - .1 Price Industries Inc.;
 - .2 Anemostat;
 - .3 Krueger Division of Air System Components Inc.;
 - .4 Titus;
 - .5 Nailor Industries Inc.;
 - .6 Tuttle & Bailey.

PART 3 - EXECUTION

3.1 Cleanliness Requirements for Handling and Installation of Ductwork

- .1 Handle and install ductwork in accordance with CSA Z317.2, Special Requirements for Heating, Ventilation, and Air-Conditioning (HVAC) Systems in Healthcare Facilities and SMACNA's Duct Cleanliness for New Construction Guidelines at the Advanced Level.

3.2 Fabrication and Installation of Galvanized Steel Ductwork

- .1 Provide required ductwork, rectangular, round and/or flat oval. Where rectangular ductwork is shown, round or flat oval ductwork of equivalent cross-sectional area is acceptable.

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- .2 It is to be understood that all duct dimensions shown on drawings are clear internal dimensions.
- .3 Unless otherwise specified, construct and install ductwork in accordance with ANSI/SMACNA HVAC Duct Construction Standards Metal and Flexible to suit duct pressure class designation of minimum 500 Pa (2" w.c.) positive or negative as applicable, a minimum velocity of 10 m/s (2000 fpm), and so ductwork does not "drum". Flat surfaces of rectangular ductwork are to be cross-broken. Duct system sealing is to meet ANSI/SMACNA Seal Class A requirements.
- .4 Variable air volume ductwork from supply fans to boxes is as above but rectangular duct take-offs are double side straight taper type with a take-off length equal to 0.5 times the branch duct width but minimum 150 mm (6") length, and double taper side is to have an included angle of minimum 60°.
- .5 Confirm routing of all ductwork at site and site measure ductwork prior to fabrication. Duct dimensions may be revised to suit site routing and building element requirements, if dimension revisions are reviewed with and approved by Consultant. Duct routing and/or dimension revisions to suit conditions at site are not grounds for a claim for an extra cost.
- .6 Refer to structural drawings. Where ductwork is to be run within or through open web steel joists, ductwork shown on mechanical drawings is schematic only and is to be altered as required to suit steel joist configuration, spacing, panel points, and cross-bridging at no additional cost.
- .7 Wherever ductwork is required at locations where sprayed fireproofing is applied to building construction, install ductwork only after fireproofing work is complete and do not compromise fire rating of sprayed fireproofing.
- .8 Install (but do not connect) duct system mounted automatic control components supplied as part of the automatic control work.
- .9 Where indicated, provide duct connections to fan powered heat transfer equipment with integral coils.
- .10 Flange connect ductwork to hot water reheat coils in accordance with requirements of ANSI/SMACNA HVAC Duct Construction Standards Metal and Flexible. Coils will be suspended independent of connecting ductwork as part of the heat transfer work.
- .11 Support horizontal rectangular ducts inside building in accordance with ANSI/SMACNA HVAC Duct Construction Standards Metal and Flexible, but use trapeze hangers with, unless otherwise specified, galvanized steel channels, and galvanized steel hanger rods for exposed ducts and concealed ducts wider than 500 mm (20"). Support hardware constructed of same material as duct for metal duct, and, unless otherwise specified, type 316 stainless steel for non-metal duct. Supports for "heavy" duct such as cementitious core duct is to be suitable in all respects for the application and approved by Consultant.
- .12 Support round and flat oval ducts inside building in accordance with ANSI/SMACNA HVAC Duct Construction Standards Metal and Flexible, but, unless otherwise specified, for both uninsulated and insulated ducts exposed in finished areas, use bands and secure at top of duct to a hanger rod, all similar to Ductmate Canada Ltd. type "BA". If duct is insulated, size strap to suit diameter of insulated duct. Unless otherwise specified, duct support hardware for metal duct is constructed of same material as duct, and for non-metal duct, type 316 stainless steel.

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- .13 Where flanged duct joints are used, do not locate joints in wall or slab openings, or immediately at wall or slab openings. Do not use flanged joints for exposed uninsulated ducts in finished areas.
- .14 Where watertight horizontal ductwork is required, construct ducts without bottom longitudinal seams. Solder or weld joints of bottom and side sheets. Seal all other joints with duct sealer. Slope horizontal duct to hoods, risers, or drain points. Provide drain points. Provide watertight ductwork for:
 - .1 ductwork outside building or otherwise exposed to the elements;
 - .2 minimum of 3 m (10') upstream and downstream of duct mounted humidifiers or humidifier manifolds;
 - .3 fresh air intakes;
 - .4 wherever else shown.
- .15 Leakage Testing:
 - .1 Ductwork leakage is not to exceed following:
 - .1 ductwork to 2" W.C. Class, 1% of total air quantity handled by respective fans;
 - .2 ductwork exceeding 2" W.C. Class, 2% of total air quantity handled by respective fans.
 - .2 Leakage testing is to be performed by the Testing, Adjusting and Balancing (TAB) agency in accordance with SMACNA HVAC Air Duct Leakage Test Manual and is to be witnessed by Consultant.
 - .3 Leakage test following ductwork:
 - .1 Riser from AHU ACS-1F down to the main floor.
 - .2 The main existing duct in the corridor of main floor, from the shaft to the new cap.
 - .3 All new ductwork as shown in the drawings.
 - .4 Be responsible for following:
 - .1 preparing duct systems for leakage testing prior to installation of external insulation including capping duct runouts and provision of final tap-in for test equipment;
 - .2 schedule testing with TAB agency in advance, be present for all testing and ensure notice is given to Consultant so they may witness testing;
 - .3 resealing and/or replacement of defective ductwork;
 - .4 bearing all costs associated with retesting ductwork which has failed to pass leakage testing.
- .16 Seal all ductwork in accordance with SMACNA Seal Class "A", except for round duct with self-sealing gasketed fittings and couplings which does not require site applied sealant. Apply sealants by brush or gun to cleaned metal surfaces. Where bare ductwork is exposed apply neat uniform lines of sealant. Randomly brushed, sloppy looking sealant applications will be rejected and must be repaired or replaced with a neat application of sealant.

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- .17 Apply sealants by brush or gun to cleaned metal surfaces. Where bare ductwork is exposed apply neat uniform lines of sealant. Randomly brushed, sloppy looking sealant applications will be rejected and must be repaired or replaced with a neat application of sealant.
- .18 Clean exterior exposed (uninsulated) ducts and coat with a heavy full coverage of Bakor #410-02 black metal paint.
- .19 Where dissimilar metal ducts are to be connected, isolate ducts by means of flexible duct connection material.
- .20 Equip ducts with a dimension of 600 mm (24") and larger and located in mechanical equipment rooms of any kind with hanger rods equipped with double deflection neoprene rod isolation hangers properly sized for associated load. Also refer to Section entitled Seismic Control and Restraint.

3.3 Installation of Flexible Ductwork

- .1 Provide maximum 3 m (10') long lengths of flexible ductwork for connections between galvanized steel duct mains and branches, and necks of ceiling grilles and diffusers. Do not install flexible ductwork through walls, even if shown on drawings.
- .2 At rectangular galvanized steel duct, accurately cut holes and provide flanged or "Spin-in" round flexible duct connection collars. Seal joints with duct sealer.
- .3 Install flexible ducts as straight as possible and support in accordance with requirements of ANSI/SMACNA HVAC Duct Construction Standards Metal and Flexible, and secure at each end with nylon or stainless steel gear type clamps, and seal joints. Provide long radius duct bends where they are required.
- .4 Do not penetrate fire barriers with flexible duct.

3.4 Installation of Round to Rectangular Duct Connections

- .1 Cut round holes in rectangular ducts and provide round to rectangular lock-in fittings with dampers for connection of flexible round ductwork.

3.5 Installation of Splitter Dampers

- .1 Provide splitter dampers in supply ductwork at branch duct connections off supply air mains, and wherever else shown and/or specified on drawings. Install splitter dampers so they cannot vibrate and rattle and so damper operation mechanisms are in an easily accessible and operable location. Ensure operators for dampers in insulated ducts are equipped with stand-off mounting brackets.

3.6 Installation of Turning Vanes

- .1 Provide turning vanes in ductwork elbows where shown on drawings and wherever else required where, due to site installation routing and duct elbow radius, turning vanes are recommended in accordance with ANSI/SMACNA HVAC Duct Construction Standards Metal and Flexible.
- .2 Provide volume extractor type turning vanes in short branch supply duct connections off mains to grilles and diffusers where shown and/or specified.

HVAC Air Distribution

3.7 Installation of Manual Balancing (Volume) Dampers

- .1 Provide manual balancing dampers as required to provide a fully balanced system, including but not limited to in all open end ductwork, in all duct mains, and wherever else shown and/or specified.
- .2 Install dampers so operating mechanism is accessible and positioned for easy operation, and so dampers cannot move or rattle. Ensure operating mechanisms for dampers in insulated ducts are complete with stand-off mounting brackets.
- .3 Where a duct for which a balancing damper is required has dimensions larger than dimensions of maximum size volume damper available, provide multiple dampers bolted together in a properly sized assembly, or bolted to a heavy-gauge black structural steel angle or channel framework which is properly sized. Seal to prevent air by-pass, and provide connecting linkage.
- .4 Confirm exact damper locations with personnel doing air quantity balancing testing work and install dampers to suit. Include for providing 5 additional dampers at no additional cost.

3.8 Installation of Backdraft Dampers

- .1 Provide backdraft dampers.
- .2 Install and secure dampers so they cannot move or rattle.

3.9 Installation of Fusible Link Dampers

- .1 Provide fusible link dampers. Ensure damper rating (1-½ or 3 hr.) is suitable for fire barrier it is associated with.
- .2 Install dampers with retaining angles on all 4 sides of sleeve on both sides of damper and connect with ductwork in accordance with damper manufacturer's instructions and details, and Code requirements.
- .3 Provide expansion clearance between damper or damper sleeve and opening in which damper is required. Ensure openings are properly sized and located, and all voids between damper sleeve and opening are properly sealed to maintain rating of fire barrier.
- .4 Where size of fire barrier opening requires use of a sectionalized fire damper assembly, provide multiple fusible link dampers (sized to CAN/ULC S112) bolted together in a properly sized assembly or bolted to a heavy-gauge black structural steel angle or channel framework.

3.10 Installation of Combination Fire/Smoke Dampers

- .1 Provide combination fire/smoke dampers. Install dampers with retaining angles on all 4 sides of each side of damper, and, where required, connect with ductwork, all in accordance with damper manufacturer's instructions and details, and Code requirements.
- .2 Coordinate damper installation with electrical work where electrical connections to damper actuators are specified.

3.11 Installation of Smoke Dampers

HVAC Air Distribution

- .1 Provide smoke dampers. Install dampers with retaining angles on all 4 sides of sleeve on both sides of damper and connect with ductwork in accordance with damper manufacturer's instructions and details, and Code requirements.
- .2 Coordinate damper installation with electrical work where electrical connections to damper actuators are specified.

3.12 Installation of Flexible Connection Material

- .1 Provide a minimum of 100 mm (4") of flexible connection material where ducts, plenums, and/or easings connect to fans, and wherever else shown or specified.
- .2 Rigidly secure a minimum of 75 mm (3") of duct material (minimum #24 gauge) to each edge of flexible fabric and to fan, duct, plenum, etc., in accordance with ANSI/SMACNA HVAC Duct Construction Standards Metal and Flexible. Ensure connections to flexible fabric material are arranged and supported so as to not impose any external forces on the fabric.

3.13 Installation of Duct Access Doors

- .1 Provide access doors in ductwork for access to all components which will or may need maintenance and/or repair, including reheat coils. Install in accordance with requirements of ANSI/SMACNA HVAC Duct Construction Standards Metal and Flexible.
- .2 Identify access doors provided for fusible link damper maintenance with "FLD" stencil painted or marker type red lettering and ensure doors are properly located for damper maintenance.
- .3 When requested, submit a sample of proposed duct access doors for review.
- .4 Where sectionalized fusible link dampers and/or balancing dampers are provided in large ducts, provide a plenum type access door to suit, and adequately reinforce ductwork to suit access door installed.

3.14 Installation of Instruments Test Ports

- .1 Provide instrument test ports in all main ducts at connections to fans, plenums or casings, in all larger branch duct connections to mains, and wherever else required for proper air quantity balancing and testing.
- .2 Locate test ports where recommended by personnel performing air quantity testing and balancing work.

3.15 Installation of Wire Mesh (Birdscreen)

- .1 Provide framed, removable wire mesh panels over openings in ducts and/or walls where shown and/or specified on drawings. Rigidly secure in place but ensure panels are removable.
- .2 Provide wire mesh panels for open-end return air ducts in ceiling spaces whether shown on drawings or not.

3.16 Installation of Louvres

- .1 Provide louvres for wall openings.

HVAC Air Distribution

- .2 Install louvre assemblies and secure in place in accordance with manufacturer's instructions and details.
- .3 Confirm exact louvre sizes and finish prior to ordering.

3.17 Installation of Louvre Blank-Off Panels

- .1 Provide blank-off panels for inactive portions of exterior wall louvres.
- .2 Secure panels in place with non-ferrous hardware so they cannot move or rattle, yet are easily removable.
- .3 Confirm exact finish of panels prior to fabrication.

3.18 Installation of Grilles and Diffusers

- .1 Provide grilles and diffusers. Wherever possible, grilles and diffusers are to be product of same manufacturer.
- .2 Unless otherwise specified connect grilles and diffusers in accordance with requirements of SMACNA HVAC Duct Construction Standards Metal and Flexible.
- .3 Exactly locate grilles and diffusers to conform to final architectural reflected ceiling plans and detailed wall elevations, and to conform to final lighting arrangement, ceiling layout, ornamental and other wall treatment.
- .4 Equip supply diffusers having a basic 4-way or all round air pattern for operation in 1-, 2-, or 3-way pattern where indicated on drawings.
- .5 Provide sheet metal plenums, constructed of same material as connecting duct, for linear grilles and/or diffusers where shown. Construct and install plenums in accordance with requirements of SMACNA HVAC Duct Construction Standards Metal and Flexible. Where individual sections of linear grilles or diffusers are not equipped with a volume control device, equip duct connection collar(s) with volume control device(s).
- .6 Where linear type diffusers/grilles are installed in suspended T-bar ceilings, clip diffusers/grilles in place using clip supplied by diffuser/grille manufacturer.
- .7 Confirm grille and diffuser finishes prior to ordering.
- .8 Refer to Section entitled Basic Mechanical Materials and Methods for equipment/system manufacturer certification requirements.
- .9 Refer to Section entitled Basic Mechanical Materials and Methods for equipment/system start-up requirements.
- .10 Include for a ½ day on-site operation demonstration and training session. Training is to be a full review of all components including, but not limited to, a full operation and maintenance demonstration.

3.19 Supply of Door Grilles

- .1 Supply door grilles as shown and scheduled.
- .2 Hand grilles to appropriate trade at site for installation.

3.20 Duct System Protection, Cleaning and Start-Up

- .1 Temporarily cover all open ends of ducts during construction.

HVAC Air Distribution

- .2 Remove all dirt and foreign matter from entire duct systems and clean duct system terminals and interior of air handling units prior to operating fans.
- .3 Prior to starting any supply air handling system provide 50 mm (2") thick glass fibre construction filters at fan equipment in place of permanent filters.
- .4 Provide cheesecloth over duct system inlets and outlets and run system for 24 hours, after which remove cheesecloth and construction filters, and install new permanent filters.
- .5 Include all labour for a complete site walk-through with testing and balancing personnel following route of all duct systems to be tested, adjusted and balanced for the purpose of confirming proper position and attitude of dampers, location of pitot tube openings, and any other work affecting testing and balancing procedures. Perform corrective work required as a result of this walk-through.

END OF SECTION

PART 1 - GENERAL

1.1 Submittals

- .1 Submit shop drawings and product data sheets for silencers. Include construction, acoustic and aerodynamic performance data, and details with submission. Include pressure drop and pressure drop with system effects data for each silencer with silencer shop drawing.
- .2 Submit acoustics analysis report with silencer shop drawing. Acoustical data is to demonstrate that duct systems with silencers will reduce mechanical fan system noise to required NC levels in occupied spaces.
- .3 Submit manufacturer's test data to indicate results of factory tests on silencers prior to shipment. Include identification that silencer acoustic media and any lining/wrapping material products have been tested to CAN/ULC S102.
- .4 Submit copy of silencer manufacturer's National Voluntary Laboratory Accreditation Program (NVLAP) accreditation certificate for latest ASTM E477 test standards.
- .5 Submit installation certification letter from silencer manufacturer as specified in Part 3 of this Section.

1.2 Quality Assurance

- .1 Silencer performance must be substantiated by laboratory testing in a duct-to-reverberant room test facility according to ASTM E477, Standard Test Method for Measuring Acoustical and Airflow Performance of Duct Liner Material and Prefabricated Silencers.
- .2 Silencer acoustic media and any lining/wrapping material must have a maximum flame spread rating of 25 and a smoke developed rating of 50 when tested in accordance with CAN/ULC S102, Surface Burning Characteristics of Building Materials, and Accessories.
- .3 Acceptable silencer manufacturers are:
 - .1 Vibro-Acoustics Ltd.;
 - .2 Price Industries Inc.

PART 2 - PRODUCTS

2.1 General Re: Silencers

- .1 Silencers are to be factory fabricated by same manufacturer and are to be in accordance with drawing schedule and tested in accordance with ASTM E477 through National Voluntary Laboratory Accreditation Program (NVLAP) with valid accreditation certificate.
- .2 Silencer inlet and outlet dimensions are to be equal to duct sizes shown on drawings. Unless otherwise shown or specified, transitions will not be permitted.
- .3 Silencers are to be constructed in accordance with SMACNA HVAC Duct Construction Standards Metal and Flexible, to suit duct system pressure and velocity classification. Unless otherwise specified, casing seams and joints are to be lock-formed and sealed or stitch welded and sealed, and silencers are to be constructed so as not to fail when subjected to an internal static pressure of 3.9 kPa (8" wg).

Silencers

- .4 Perforated steel is to be adequately stiffened to ensure flatness and form, and welds are to be shop painted with zinc rich paint.
- .5 Silencers are to be shipped with factory installed end caps.
- .6 Galvanized steel is to be in accordance with ASTM A653.

2.2 Outer Casing Materials

- .1 Rectangular Straight and Transitional Straight Silencers: Minimum #22 gauge lock forming quality galvanized steel.
- .2 Elbow and Transitional Elbow Silencers: Minimum #18 gauge for elbow lock forming quality galvanized steel.
- .3 High Transmission Loss (HTL) Rectangular and Elbow Silencers: stitch-welded and caulked galvanized steel with gauge in accordance with drawing schedule.
- .4 Circular Silencers: Lock forming quality galvanized steel with minimum gauges as follows:
 - .1 300 mm to 457 mm (12" to 18") dia. – #22 gauge;
 - .2 457 mm to 762 mm (18" to 30") dia. – #20 gauge;
 - .3 762 mm to 1.37 m (30" to 54") dia. – #18 gauge;
 - .4 over 1.37 m (54") dia. – #16 gauge.

2.3 Inner Perforated Metal Liner

- .1 Rectangular Silencers: Minimum #26 gauge, ASTM A653, G90 galvanized sheet steel.
- .2 Rectangular Elbow Silencers: Minimum #22 gauge, ASTM A653, G90 galvanized sheet steel.
- .3 Circular Silencers:
 - .1 Connection diameter up to 457 mm (18"): Minimum #26 gauge, ASTM A653, G90 galvanized sheet steel.
 - .2 Connection diameter greater than 457 mm (18"): Minimum #22 gauge, ASTM A653, G90 galvanized sheet steel.

2.4 Interior Baffle Transition

- .1 Transitioning for interior transition silencers is to occur internal to silencer such that height of air passage is uniformly changing with the length of the air passage.

2.5 Acoustic Media Material

- .1 Cotton Fibre Insulation
 - .1 For silencers as specified and/or scheduled, acoustic quality cotton fibre insulation consisting of natural cotton fibres treated with an EPA registered, non-toxic borate solution, and "flash dried" to actively inhibit the growth of mould, mildew, bacteria and fungi. Media is to not contain any formaldehydes, phenolic resins or Volatile Organic Compounds (VOC's) that can off-gas and/or cause health concerns.

Silencers

- .2 Insulation is to be packed with minimum of 15% compression during silencer assembly and not cause or accelerate corrosion of aluminum or steel.
- .3 Glass fibre, fiberglass and mineral wool is not permitted as substitute for cotton fibre insulation.

2.6 Acoustic Media Protection Material

.1 Film Lined Silencers

- .1 Acoustic media is to be completely wrapped with film to help prevent shedding, erosion and impregnation. Wrapped acoustic media is to be separated from perforated metal by factory installed 12 mm (½") thick acoustically transparent spacer. Spacer is to be flame retardant and erosion resistant. A mesh, screen or corrugated perforated liner will not be acceptable as a substitute for specified spacer.

2.7 High Transmission Loss Casings

- .1 High transmission loss (HTL) casings for silencers as scheduled are to be externally shop applied, and completely sealed to silencer casing. HTL walls are to consist of media, air space, mass, and outer protective metal skin as required to obtain room noise criteria.

PART 3 - EXECUTION

3.1 Installation of Silencers

- .1 Provide silencers. Install silencers with airflow arrows in direction of airflow.
- .2 Support each silencer independent of connecting ductwork.
- .3 Properly layout ductwork for silencer locations to provide minimum of 5 diameters of straight duct upstream of silencer and 10 diameters of straight duct downstream of silencer.
- .4 Unless otherwise specified, do not install silencers in walls or slabs.
- .5 Seal silencer connections to ducts with proper fire/smoke rated duct sealer.
- .6 When silencer installations are complete, provide for silencer manufacturer to examine silencer installations. Perform any corrective work required by manufacturer, then obtain from manufacturer and submit a signed letter certifying proper installation and operation of silencers. Submit minimum one hard copy and electronic pdf version to Consultant.

END OF SECTION

HVAC Fans

PART 1 - GENERAL

1.1 Submittals

- .1 Submit shop drawings/product data sheets for fans and accessories. Include following:
 - .1 certified fan performance curves at specified operating point with flow, static pressure and HP clearly plotted;
 - .2 certified sound power data that conforms to specified levels;
 - .3 product data sheets for all accessories;
 - .4 product data sheets for fan motors.
- .2 Submit with delivery of each unit a copy of the factory inspection report, and include a copy of each report with O&M Manual project close-out data.
- .3 Submit a site inspection and start-up report from manufacturer's representative as specified in Part 3 of this Section.
- .4 Submit a signed copy of ceiling mounted fan manufacturer's extended 3 year warranty.

1.2 Quality Assurance

- .1 Fan manufacturers, as applicable, are to be current members of the Air Movement and Control Association International Inc. (AMCA), and fans are to be rated (capacity and sound performance) and certified in accordance with requirements of following standards:
 - .1 AMCA Standard 99, Standards Handbook.
 - .2 AMCA Standard 210, Laboratory Method of Testing Fans for Certified Aerodynamic Performance Rating;
 - .3 AMCA Standard 211, Product Rating Manual for Fan Air Performance;
 - .4 ANSI/AMCA Standard 300, Reverberant Room Method for Sound Testing of Fans;
 - .5 AMCA Standard 311, Product Rating Manual for Fan Sound Performance;

PART 2 - PRODUCTS

2.1 Centrifugal Inline Fans

- .1 Centrifugal, ULC listed, factory run tested rectangular inline fans in accordance with drawing schedule.
- .2 Heavy-gauge galvanized steel housing with removable side panels to permit removal of power assembly without disturbing duct connections, universal mounting brackets and hardware including spring vibration isolators to accommodate horizontal or vertical mounting as required, a flanged inlet panel with inlet venturi, a flanged outlet panel, both with duct connection collars, and galvanized steel wire grid fan inlet/outlet guard(s).
- .3 Non-overloading aluminium wheel with backward inclined blades with matching inlet venturi, statically and dynamically balanced as an assembly.

HVAC Fans

- .4 For belt-drive fans only, hot rolled steel shaft, accurately turned, ground, and polished, and sized for a first critical speed of at least 1.25 times maximum rated speed for fan, and heavy-duty, self-aligning pillow block type bearings selected for an AFBMA L-50 minimum average life in excess of 500,000 hours and equipped with lubrication line and fitting, and an adjustable V-belt drive with guard conforming to requirements of Section entitled Basic Mechanical Materials and Methods.
- .5 TEFC motor conforming to requirements specified in Section entitled Basic Mechanical Materials and Methods, mounted out of the airstream, complete with a cover, and factory pre-wired to a NEMA 4 disconnect switch.
- .6 For fans as scheduled, factory supplied accessories as follows:
 - .1 for fans as scheduled, housing insulation (lining), consisting of neoprene spray coated glass fibre semi-rigid insulation meeting NFPA 90A requirements and 25/50 flame spread/smoke developed ratings when tested in accordance with CAN/ULC S102, permanently secured in place with no exposed edges;
 - .2 for fans as scheduled, a galvanized steel filter box with frame suitable for 25 mm (2") thick disposable panel type filters;
 - .3 factory secured seismic restraint connection hardware.
- .7 Acceptable manufacturers are:
 - .1 Twin City Fan and Blower;
 - .2 Loren Cook Co.;
 - .3 Greenheck Fan Corp.;
 - .4 JencoFan;
 - .5 Carnes Company Inc.

PART 3 - EXECUTION

3.1 Installation of Centrifugal Inline Fans

- .1 Provide inline centrifugal fans.
- .2 Secure each fan in place from structure with vibration isolation, independent of connecting ductwork and in accordance with fan manufacturer's instructions.
- .3 Brace and secure each unit in accordance with requirements specified in Section entitled Seismic Control and Restraint.
- .4 Ensure duct connections are made using flexible connection material.
- .5 Refer to Section entitled Basic Mechanical Materials and Methods for equipment/system manufacturer certification requirements.
- .6 Refer to Section entitled Basic Mechanical Materials and Methods for equipment/system start-up requirements.
- .7 Include for a 4 hour on-site operation demonstration and training session. Training is to be a full review of all components including but not limited to a full operation and maintenance demonstration, with abnormal events.

END OF SECTION

Air Terminal Units

PART 1 - GENERAL

1.1 Submittals

- .1 Submit shop drawings/product data sheets for air terminals. Include following:
 - .1 capacity and pressure drop;
 - .2 sound power data to verify conformance with specified sound power levels;
 - .3 leakage and dimensions;
 - .4 mounting details to suit locations shown, indicating methods and hardware to be used;
 - .5 control components and a control wiring schematic.
- .2 Submit with shop drawings/product data, a test report in accordance with ANSI/AMCA 210 requirements and ISO 3741, published test data on DIN (Direct Internal Noise) made by an independent testing agency for 2.5 and 6 m/s (8.2 and 19.7 ft/min) branch velocity or inlet velocity, sound power levels with a minimum inlet pressure of 0.25 kPa (0.036 psi) in accordance with ISO 3741 for the 2nd through 7th octave bands, and confirmation pressure loss through a silencer will not exceed 60% of inlet velocity pressure maximum.
- .3 Submit a site inspection and start-up report from manufacturer's representative as specified in Part 3 of this Section.

1.2 Quality Assurance

- .1 Air terminals manufacturers are to be current members of Air-Conditioning, Heating and Refrigeration Institute (AHRI), and terminals are to be in accordance with requirements of following standards:
 - .1 ANSI/AHRI Standard 880, Performance Rating of Air Terminals;
 - .2 ANSI/AMCA Standard 210, Laboratory Method of Testing Fans for Certified Aerodynamic Performance Rating;
 - .3 International Organization of Standardization (ISO) Standard 3741, Acoustics-Determination of Sound Power Levels of Noise Sources Using Sound Pressure-Precision Methods for Reverberation Rooms.
- .2 Equip boxes with factory secured seismic restraint connection hardware.
- .3 Acceptable manufacturers are:
 - .1 Price Industries Inc.;
 - .2 Titus;
 - .3 Nailor Industries Inc.;
 - .4 Krueger Division of Air System Components Inc

PART 2 - PRODUCTS

2.1 Constant Volume Terminal Boxes

Air Terminal Units

- .1 Single duct constant volume by-pass boxes in accordance with drawing schedule, each complete with:
 - .1 #22 gauge galvanized steel housing, sealed and gasketed, and complete with:
 - .1 internally lined with 25 mm (1") thick fibre-free foam lining material meeting NFPA 90A and 25/50 flame spread/smoke developed ratings when tested in accordance with CAN/ULC S102;
 - .2 galvanized steel attenuators, lined as per box housings, each factory supplied loose and with a length in accordance with drawing schedule;
 - .3 factory tested hot water reheat coils in accordance with drawing schedule, each complete with copper tubes mechanically expanded into plate type aluminum fins, factory mounted in an enclosure insulated with foil faced insulation meeting NFPA 90A and 25/50 flame spread/smoke developed ratings when tested in accordance with CAN/ULC S102, and complete with a quick-opening insulated access panel sized and located for coil inspection and maintenance;
 - .4 actuator supplied as part of controls work specified in Section entitled Automatic Control Systems, shipped to box manufacturer's plant by controls supplier, and factory installed and connected by box manufacturer;
 - .5 wall mounting thermostat with thermometer and guard, supplied with boxes by box manufacturer, suitable in all respects for box it controls and control sequence, and complete with all required installation and connection accessories.

PART 3 - EXECUTION

3.1 Installation of Terminal Boxes

- .1 Provide ceiling mounted terminal boxes.
- .2 Secure each box in place from structure by means of galvanized steel angles and hanger rods, independent of connecting ductwork.
- .3 Brace and secure each unit in accordance with requirements specified in Section entitled Seismic Control and Restraint.
- .4 Coordinate provision of transformers, actuators and controllers with Controls Contractor.
- .5 Connect each box with ductwork as indicated. Provide straight inlet duct same size as box inlet and of a length equal to a minimum of 4 duct diameters. Refer to drawing detail. Coordinate final box adjustments and settings with personnel doing system testing and balancing work.
- .6 Refer to Section entitled Basic Mechanical Materials and Methods for equipment/system start-up requirements.
- .7 Include for a 1/2 day on-site operation demonstration and training session. Training is to be a full review of all components including, but not limited to, a full operation and maintenance demonstration, and setting and adjusting controls.

END OF SECTION

PART 1 - GENERAL

1.1 Submittals

- .1 Submit shop drawings/product data sheets for all products specified in this Section.
- .2 Prior to Substantial Performance of the Work, submit a set of spare filters in original identified packaging for each air handling unit requiring filters. Store filters on site where directed by Consultant or Owner.
- .3 Prior to Substantial Performance of the Work, submit a spare bottle of red manometer filter gauge oil, with instructions, to Owner for each manometer type gauge installed.

PART 2 - PRODUCTS

2.1 General

- .1 Unless otherwise specified or noted, filters are to be synthetic and/or glass fibre disposable media type in accordance with drawing schedule(s).
- .2 Minimum Efficiency Reporting Values (MERV) ratings in accordance with ASHRAE Standard 52.2, Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Sizes.
- .3 Unless otherwise specified or noted, filters are to be ULC Class 1 in accordance with ULC S111, Standard Method of Fire Tests for Air Filter Units.
- .4 Acceptable manufacturers are:
 - .1 AAF International;
 - .2 Camfil Farr Inc.;
 - .3 Modern Air Filter Corp.

2.2 Construction Filters

- .1 Roll type, disposable, MERV 7 to 9 woven glass fibre media, ULC Class 2.

2.3 Hepa Filters

- .1 HEPA high capacity filters in accordance with drawing schedule and UL Standard 586, High-Efficiency, Particulate, Air Filter Units, 99.995% efficient on 0.12 µm particles, consisting of a continuous pleating of water-proof micro glass fibre media with pleats uniformly separated by aluminum separators, urethane sealant to encapsulate the filter pack in minimum #16 gauge galvanized steel frame with one-piece urethane gasket or neoprene dove-tailed gasket for positive leak-free filter-to-holding mechanism seal.

2.4 Filter Framing and Racks

- .1 No. 16 gauge galvanized steel filter framing/racks, sized and arranged to suit filters and filter bank, easily accessible for filter service and replacement, and complete with slide-in tracks or lay-in flanges as required for filter placement, and all required gasketing and facilities to prevent air by-pass.

2.5 Inclined Manometer Air Filter Gauge

Air Filters and Accessories

- .1 Dwyer Instruments Inc. Model 250.5-AF inclined tube differential pressure type filter gauge of solid acrylic construction, complete with vent valves for zeroing, built-in level vial, over-pressure safety traps, adjustable mirror polished scale, and 2, 1.5 m (5') lengths of 6.4 mm (1/4") dia. tubing, 2 static pressure tips, mounting hardware, and a spare bottle of red gauge oil and instructions.

PART 3 - EXECUTION

3.1 Installation of Construction Filters

- .1 Provide roll type medium efficiency disposable media filter(s) across entire filter bank of each supply air handling unit, either at factory where fan is produced or at site as soon as fan is installed. Secure media in place so it will not be dislodged by fan operation. Replace roll media periodically if it becomes loaded and clogged.
- .2 For exhaust systems, secure filter media across exhaust air openings and ductwork to prevent construction dirt and dust from fouling the fan
- .3 Leave media in place until fan start-up, at which time remove and dispose of construction media.

3.2 Installation of Filters

- .1 Provide required filter media when fan equipment is ready for start-up and performance testing. Provide any required filter framing/racks.
- .2 Prior to Substantial Performance of the Work, supply a complete spare set of filter media in original packaging and clearly identified as to the applicable system for each air handling system with filters. Store filters at site where directed by Owner.

3.3 Installation of Inclined Manometer Filter Gauges

- .1 Provide an inclined manometer filter gauge for air handling system filter banks.
- .2 Secure gauge to filter section casing and install differential pressure tubing and tips. Fill gauges with red oil and adjust as required.
- .3 Affix a red arrow to scale so it indicates point on scale where filters are clogged and require replacement.

3.4 Installation of Dial Type Filter Gauges

- .1 Provide dial type filter gauges for air handling system filter banks.
- .2 Secure gauge to filter section casing and install differential pressure tubing and accessories. Set gauges to suit fresh clean filter media and mark scales at point where filter media requires replacement.

END OF SECTION

Fan Coil Units

PART 1 - GENERAL

1.1 Submittals

- .1 Submit shop drawings/product data sheets for products specified in this Section. Include motor data sheets and required information.
- .2 Submit site inspection and start-up report from manufacturer's representative as specified in Part 3 of this Section.

1.2 Quality Assurance

- .1 Fan coil units are to be CSA or ETL listed and labelled, factory assembled and tested, shipped to site in one-piece, and are to be in accordance with requirements of following Codes and Regulations:
 - .1 CAN/CSA-C22.2 No. 236, Heating and Cooling Equipment;
 - .2 UL/ANSI 1995, Heating and Cooling Equipment;
 - .3 ANSI/AHRI Standard 350, Sound Performance Rating of Non-Ducted Indoor Air-Conditioning Equipment;
 - .4 ANSI/AHRI Standard 440, Performance Rating of Room Fan-Coils;
 - .5 applicable Provincial Codes and Regulations.

PART 2 - PRODUCTS

2.1 Horizontal Fan Coil Units

- .1 AHRI rated and certified capacity fan coil units in accordance with drawing schedule and complete with components specified below.
- .2 Cabinet constructed of heavy-gauge galvanized steel with exterior panels insulated with minimum 15 mm (½") thick neoprene spray coated glass fibre lining material secured in place with adhesive and with all exposed edges treated and sealed to prevent any fibres from entering airstream, all meeting NFPA 90A requirements and 25/50 flame spread/smoke developed fire hazard ratings when tested to CAN/ULC S102. Each cabinet is to be complete with:
 - .1 accessible galvanized steel filter holding frame and glass fibre, 25 mm (1") thick, disposable, UL Class 1, 25-30% efficient MERV 7 filters in accordance with requirements of UL 900, Air Filter Units, and complete with a cardboard frame;
 - .2 factory tested coils consisting of 12 mm (½") O.D. seamless copper tubes mechanically expanded into plate type aluminium fins and equipped with copper pipe headers, a manual air vent, and a drain plug;
 - .3 full width, watertight stainless steel primary drain pans sloped for positive drainage and equipped with 2, 20 mm (¾") O.D. drain connections, and factory insulated with 25/50 flame spread/smoke developed rated closed cell insulation when tested to CAN/ULC S102 and NFPA 90A requirements, with secondary drain pans, constructed and insulated as for primary drain pans, to be provided where required to collect condensate from pipe headers and field supplied valves.

Fan Coil Units

- .3 Centrifugal, forward curved, double width and inlet galvanized steel fan wheel, each dynamically balanced, complete with a 3-speed, resiliently mounted, thermal overload protected, permanent split capacitor motor conforming to requirements specified in Section entitled Basic Mechanical Materials and Methods, and complete with a 3-speed plus "off" motor control switch with faceplate factory mounted in an electrical box secured to unit in an accessible location and factory connected to motor. Fan assemblies are to be accessible and easily removable.
- .4 Horizontal units are to be suspended, equipped with 4 top casing holes for hanger rod connections, and following:
 - .1 rubber-in-shear vibration isolation elements factory supplied with each unit for each suspension point;
 - .2 double deflection discharge grille or flanged discharge duct connection collar as indicated, and either a bottom or rear single deflection return air grille as shown;
 - .3 removable bottom and side panels, and bottom access to filter holding frame;
 - .4 for exposed units, a fused powder epoxy finish on casing and grilles.
- .5 Seismic restraint connection hardware factory secured to each unit.

PART 3 - EXECUTION

3.1 Installation of Fan Coil Units

- .1 Provide fan coil units.
- .2 Secure each horizontal fan coil unit in place from structure by means of galvanized steel hanger rods, and vibration isolation elements supplied with fan coil units. Provide additional structural steel for fan coil unit support installation as required.
- .3 Provide shut-off valves and install a control valve in piping for each coil. Refer to drawing detail and piping schematic.
- .4 Refer to Section entitled Basic Mechanical Materials and Methods for equipment/system manufacturer certification requirements.
- .5 Refer to Section entitled Basic Mechanical Materials and Methods for equipment/system start-up requirements.
- .6 Include for a 1/2-day on-site operation demonstration and training session. Training is to be a full review of all components including but not limited to a full operation and maintenance demonstration, with abnormal events.
- .7 Brace and secure each unit in accordance with requirements specified in Section entitled Seismic Control and Restraint.

END OF SECTION

Duct Mounted Heating Coils

PART 1 - GENERAL

1.1 Submittals

- .1 Submit shop drawings/product data sheets for heating coils, including accessories.

PART 2 - PRODUCTS

2.1 Duct Mounted Hydronic Heating Coils

- .1 Hydronic coils in accordance with drawing schedule, 1 or 2 row as indicated, each certified to AHRI Standard 410, Forced-Circulation Air-Cooling and Air-Heating Coils, each factory leakage tested at 2070 kPa (300 psi) under water, drainable, self-venting, and complete with:
 - .1 horizontal, continuous, 15.9 mm (5/8") diameter, 0.050 mm (0.020") wall thickness seamless copper tubes permanently bonded to plate or spirally wound aluminium fins and equipped with threaded female same end connections;
 - .2 flanged galvanized steel casing arranged to prevent air bypass around coil and factory punched for duct connections.
- .2 Where required, coils are to be manufactured as "Registered Fittings" with a Canadian Registration Number (CRN).
- .3 Acceptable manufacturers are:
 - .1 Aerofin Canada Services Inc.;
 - .2 Carrier Corp.;
 - .3 Daikin.
 - .4 EH Price

PART 3 - EXECUTION

3.1 Installation of Duct Mounted Hydronic Heating Coils

- .1 Provide duct mounting heating coils in supply ductwork.
- .2 Secure each coil in place from structure by means of hanger rods, independent of connecting ductwork but ready for duct connection and located for easy removal and access to power and control panel.
- .3 Connect with piping in accordance with drawing detail.

END OF SECTION

Automatic Control Systems

PART 1 - GENERAL

1.1 Submittals

- .1 Submit shop drawings/product data sheets for following:
 - .1 all control system components;
 - .2 identified schematic control diagrams with component identification, catalogue numbers, and sequence of operation for all systems;
 - .3 certified wiring diagrams for all systems.
- .2 Submit following samples for review:
 - .1 control damper section with linkage, operator, and certified flow and leakage data;
 - .2 wall mounting control system flow diagram as specified in Part 2 of this Section;
 - .3 each type of thermostat to be used, each identified as to intended use.
- .3 Submit a site inspection and start-up report from manufacturer's representative as specified in Part 3 of this Section.
- .4 Submit written confirmation from control component manufacturer that site installation personnel are qualified and experienced in installation of components, and have parts and service availability on a 24/7 basis.

1.2 Quality Assurance

- .1 Control systems are to be installed by control component manufacturer or by licensed personnel authorized by control component manufacturer. Submit written confirmation from control component manufacturer.
- .2 Control system installation company is to have local parts and service availability on 24/7 basis.
- .3 Control wiring work is to be performed by licensed journeyman electricians, or under direct daily supervision of journeyman electricians.

PART 2 - PRODUCTS

2.1 Air Compressor Set and Accessories

- .1 Package type, duplex, receiver mounted, automatic, CSA certified air compressor set selected to meet all requirements of control system while operating not more than 33% of the time with a maximum of 6 starts per hour. Compressor set complete with a low resistance air intake filter/silencer, and motors and V-belt drives with guards in accordance with requirements of Section entitled Basic Mechanical Materials and Methods, and following:
 - .1 suitably sized, ASME rated and stamped steel receiver in accordance with CSA B51 and Provincial requirements with support feet, rubber-steel-rubber type vibration isolation pads, automatic tank drain, adjustable pressure switch, safety relief valve, check valve, self-lubricating ball type outlet valve, manual drain valve, and a flexible tank to air piping flexible connection supplied loose for site installation;

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- .2 separate (supplied loose) surface wall mounting starter and control panel factory pre-wired for single point site connection of electric power, complete with NEMA 2 enclosure, door interlock disconnect switch, a fused overload protected magnetic starter for each motor, control transformer, 2 NO and 2 NC auxiliary contacts, a green "power on" LED and a white LED for each working compressor, and an alternator to automatically alternate the working compressor after each start and to automatically start lag compressor if working compressor fails;
 - .3 packaged type refrigerated air dryer sized to suit and supplied loose for site installation, complete with hot gas by-pass to maintain continuous operation and stable dew point, power on and high temperature indicating lights, overload protected motor starter, an integral automatic condensate drain trap, and a manual 3-valve by-pass to permit removal of heat exchanger for servicing without disrupting control system;
 - .4 coalescing type oil removal filter supplied loose by compressor set manufacturer for site installation, sized to control air piping main size, and equipped with automatic drain and an indicator piping kit for media maintenance inspection.
- .2 Acceptable manufacturers are:
- .1 DeVilbiss (Canada) Ltd.;
 - .2 Compair Kellog;
 - .3 Atlas Copco Compressors Canada.

2.2 Control Dampers and Operators

- .1 T. A. Morrison & Co. Inc. "TAMCO" 100 mm (4') deep, flanged, AMCA low leakage certified aluminium dampers. Dampers for modulating and mixing applications are to be opposed blade type. Dampers for open-shut service are to be parallel blade type. Maximum blade length is to be 1 m (4'). Dampers greater than 2 sections wide are to be complete with jackshaft. Each damper is to be complete with:
 - .1 extruded 6063T5 aluminum frame and airfoil blades, each with an integral slot to receive a gasket;
 - .2 extruded TPE frame gaskets and extruded EPDM blade gaskets;
 - .3 slip-proof aluminium and corrosion resistant plated steel linkage of metal thickness to prevent warping or bending during damper operation, concealed in frame, equipped with self-sealing and self-lubricating bearings consisting of Celcon inner bearing fixed on hexagonal blade pin and rotating in polycarbonate outer bearing inserted in frame.
- .2 For standard damper(s), Series 1000 as above.
- .3 For insulated damper(s), Series 9000 as above but with all 4 sides of frame insulated with polystyrene, and blades thermally broken and insulated with expanded polyurethane foam.

2.3 Local Control Panels

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- .1 NEMA 1 (NEMA 2 in sprinklered areas) wall mounting, enamelled steel barriered enclosures sized to suit the application with 20% spare capacity, perforated sub-panel, numbered terminal strips for all low and line voltage wiring, hinged door, and slotted flush latch.

2.4 Control System Components

- .1 Components specified below are required for control of equipment and systems in accordance with drawing control diagrams and sequences of operation. Not all required components may be specified.
- .2 Sensor/transmitter input devices to be suitable in all respects for application and mounting location. Devices are as follows:
 - .1 unless otherwise specified, temperature sensors are to be resistance type, either 2-wire 1000 ohm nickel RTD or 2-wire 1000 ohm platinum RTD with accuracy (includes errors associated with sensor, lead wire, and A to D conversion), equipped with type 316 stainless steel thermowells for pipe mounting applications, as follows:
 - .1 chilled water, room temperature, and duct temperature points, $\pm 1^{\circ}\text{C}$ ($\pm 0.5^{\circ}\text{F}$);
 - .2 all other points, $\pm 0.75^{\circ}\text{C}$ ($\pm 1.3^{\circ}\text{F}$).
 - .2 room temperature sensors constructed for surface or recessed wall box mounting, complete with an adjustable set-point reset slide switch with a $\pm 1.66^{\circ}\text{C}$ ($\pm 3^{\circ}\text{F}$) range, individual heating/cooling set-point slide switches as required, momentary override request pushbutton for activation of after-hours operation, an analogue thermometer;
 - .3 outside air sensors designed and constructed for ambient temperatures and to withstand environmental conditions to which they are exposed, complete with NEMA 3R enclosure, solar shield, and a perforated plate surrounding sensor element where exposed to wind velocity pressure;
 - .4 insertion duct mounting sensors type with lock nut and mounting plate, designed to mount in an electrical box (weather-proof with gasket and cover where outside) through a hole in duct;
 - .5 for ducts greater than 1.2 m (4') or for ducts where air temperature stratification occurs, averaging type sensors with multiple sensing points, and for plenums for applications such as mixed air temperature measurement to account for air turbulence and/or stratification, averaging string of sensors with capillary supports on sides of duct/plenum;
 - .6 factory solid-state relative humidity sensors with element that resists contamination, weather-proof with NEMA 3R enclosure for outside air applications, supplied with type 304 stainless steel probe with mounting bracket and hardware for duct mounting, each complete with factory calibrated humidity transmitter which is accurate (including lead loss and analog to digital conversion) to 3% between 20% to 80% RH at 25°C (77°F) and equipped with non-interactive span and zero adjustments, and 2-wire isolated loop powered, 4-20 mA, 0 to 100% linear proportional output;

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- .7 carbon dioxide sensors for air quality control purposes having a maximum 20 second response time, suitable for operating conditions from 0°C to 50°C (32°F to 122°F) and 0 to 100% RH non-condensing, complete with a calibration kit (to be handed to Owner) and characteristics as follows:
 - .1 measurement range: 0 to 2000 ppm;
 - .2 accuracy: ± 100 ppm;
 - .3 repeatability: ± 20 ppm;
 - .4 drift: ± 100 ppm per year;
 - .5 output signal: 0 to 10 VDC proportional over the 0 to 2000 ppm range.
- .3 Pressure transmitters are to be constructed to withstand 100% pressure over-range without damage and to hold calibrated accuracy when subject to a momentary 40% over-range input. Pressure transmitters are to transmit a 0 to 5 VDC, 0 to 10 VDC, or 4 to 20 mA output signal. Differential pressure transmitters used for flow measurement are to be sized to the flow sensing device and supplied with a tee fitting and shut-off valves in the high and low sensing pick-up lines to allow permanent ease of use connection for balancing, etc. Transmitter housing is to suit mounting location. Standalone pressure transmitters are to be mounted in a minimum NEMA 1 (NEMA 2 in sprinklered area) by-pass valve assembly panel with high and low connections piped and valved, air bleed units, by-pass valves, and compression fittings. Transmitters are to be as follows:
 - .1 low differential water pressure, 0 to 5 kPa (0 to 20" wc): equal to Setra or Mamac industrial quality transmitter capable of transmitting a linear 4 to 20 mA output in response to variation of flow meter differential pressure or water pressure sensing points, each complete with non-interactive zero and span adjustments adjustable from outside the cover, and performance as follows:
 - .1 maintain accuracy up to 20 to 1 ratio turndown;
 - .2 reference accuracy: +0.2% of full scale.
 - .2 medium to high differential water pressure, over 5 kPa (20" wc): Setra or Mamac or approved equal, transmitters as specified above for low pressure transmitters but with a pressure range of from 2.5 kPa (10" wc) to 2070 kPa (300 psi), a reference accuracy of $\pm 1\%$ of full span (includes non-linearity, hysteresis, and repeatability);
 - .3 building differential air pressure: Setra or Johnson Controls Inc. or approved equal, industrial quality transmitter with a range suitable for the application, capable of transmitting a linear 4 to 20 mA output in response to variation of differential pressure or air pressure sensing points, each complete with non-interactive zero and span adjustments adjustable from outside the cover, and performance as follows:
 - .1 maintain accuracy up to 20 to 1 ratio turndown;
 - .2 reference accuracy: +0.2% of full span.

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- .4 low differential air pressure, 0 to 1.25 kPa (0" to 5" wc): Setra or Johnson Controls Inc. or approved equal, industrial quality transmitter with a range suitable for the application, capable of transmitting a linear 4 to 20 mA output in response to variation of differential pressure or air pressure sensing points, each complete with non-interactive zero and span adjustments adjustable from outside the cover, and performance as follows:
 - .1 maintain accuracy up to 20 to 1 ratio turndown;
 - .2 reference accuracy: +0.2% of full span.
- .5 medium differential air pressure, over 1.5 kPa (5" wc): Setra or Johnson Controls Inc. or approved equal, transmitters as specified above for low pressure air transmitters, but performance requirements as follows:
 - .1 zero and span: (c/o F.S./Deg. F); .04% including linearity, hysteresis, and repeatability;
 - .2 accuracy: 1% F.S. (best straight line); static pressure effect: 0.5% F. S.;
 - .3 thermal effects: <+0.33 F.S./°F over 40°F to 100°F (calibrated at 70°F).
- .4 Air and water flow monitoring stations and probes are to be Air Monitor Corp., Tek-Air Systems Inc., Ebtron, or Dietrich Standard products as follows:
 - .1 Fan Inlet Air Flow Measuring Station: At fan inlet and near exit of inlet sound trap, air flow traverse probes are to continuously monitor fan air volume and system velocity pressure, and traverse probes are to be as follows:
 - .1 each probe is to be of a dual manifold, cylindrical, anodized type 3003 extruded aluminium construction probe with sensors located along the stagnation plane of approaching air flow, and the static pressure manifold is to incorporate dual offset static tops on opposing sides of averaging manifold so as to be insensitive to flow angle variations for as much as $\pm 20^\circ$ in approaching air stream;
 - .2 each probe is not to introduce a measurable pressure drop, nor is sound level within duct to be amplified by its singular or multiple presence in air stream, and each probe is to contain multiple static and total pressure sensors places at equal distances along its length in accordance with ASHRAE Standards for duct traversing.
 - .2 Single Probe Air Flow Measuring Sensor: Duct mounting hot wire anemometer type which utilizes 2 temperature sensors, one is a heater element temperature sensor and the other is to measure downstream temperature, with temperature differential related directly to air flow velocity. Sensor insertion length is to be adjustable up to 200 mm (8"), and transmitter is to produce a 4 to 20 mA or 0 to 10 VDC signal linear to air velocity.
 - .3 Duct Flow Measuring Stations: #14 gauge galvanized steel casing with duct connection flanges of a size to mate with connecting ductwork, and complete with an air directionalizer and a 98% free area parallel cell 20 mm ($\frac{3}{4}$ ") honeycomb profile suppressor across entering air stream to equalize velocity profile and eliminate turbulent and rotational flow from the air stream prior to measuring point, mechanically fastened to casing so as to withstand velocities of up to 1828 m (6000') per minute. Additional requirements as follows:

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- .1 total pressure measurement side (high side) is to be designed and spaced to requirements of Industrial Ventilation Manual, 16th Edition, page 9-5, and self-averaging manifolding is to be constructed of brass and copper components;
 - .2 static pressure sensing probes (low side) is to be bullet-nose shaped, per detailed radius, as illustrated in Industrial Ventilation Manual referred to above, page 9-5;
 - .3 main take-off point from both total pressure and static pressure manifolds is to be symmetrical, and manifolds are to terminate with external ports for connection to control tubing;
 - .4 each station is to be equipped with a label on casing indicating unit model number, size, area, and specified air flow capacity;
 - .5 each station is to have a self-generated sound rating of less than NC 40, and sound level within duct is not to be amplified nor is additional sound to be generated.
- .4 Static Pressure Traverse Probe: Duct mounting, complete with multiple static pressure sensors located along exterior surface of cylindrical probe.
- .5 Shielded Static Air Probe: Indoor type or outdoor type as required, each with multiple sensing ports, an impulse suppression chamber, and air flow shielding.
- .6 Water Flow Monitoring: Equal to Onicon microprocessor-based electromagnetic water flow meters with an accuracy of 0.25%.
- .5 Power (amps) monitoring is to be performed by a combination of a current transformer and a current transducer with transformer sized to reduce full amperage of monitored circuit to a maximum 5 ampere signal which will be converted to a 4 to 20 mA DDC compatible circuit for use by building automation system. Current transformer and current transducer are as follows:
- .1 equal to Veris Industries split core current transformer with an operating frequency of from 50 to 400 Hz, 0.6 Kv class, 10 Kv BIL insulation, and 5 ampere secondary;
 - .2 equal to Veris Industries current to voltage or current to mA transducer with an accuracy of $\pm 5\%$, a minimum load resistance of 30 kOhm, an input of 0 to 20 amperes and an output of 4 to 20 mA, and a 24 VDC regulated power supply.
- .6 Duct mounting smoke detectors supplied as part of electrical work for mounting as part of control system work.
- .1 3 internal DPDT relays rated at 5 amperes at 30 VDC, at fully programmable alarm levels and within programmable time delays, and capable of activating multiple relay modules of 8 external relays each at programmable alarm set-points and time delays;
 - .2 alphanumeric display indicating concentration and type of gas detected as well as location of sensor/transmitter, and 2 alarm levels for each sensing point;
 - .3 identified LED's to indicate Power, Alarm Levels A, B and C, and/or Fault;
 - .4 audible alarm rated at minimum 65 dBA at 1 m (3') that will fully activate at programmable levels;

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- .5 3 levels of continuous diagnostics to verify reading of each sensor/transmitter for abnormal sensing behaviour, loss of communication between control panel and sensor/transmitter, and program corruption analysis;
 - .6 capability of long term data logging to determine trends;
 - .7 capability of output communication through BACnet/IP to building automation system to monitor system status and to view logged historical data.
- .2 Carbon Monoxide Sensor/Transmitter: Model E3SB-E3Sco wall mounting 24 volt AC at 250 mA sensor with a NEMA 4 enclosure, a protective cover-plate which will not restrict sensor operation, and following:
 - .1 microprocessor-based, factory calibrated, ambient humidity and temperature compensated CO element capable of producing a RS-485 digital serial loop output signal to control panel;
 - .2 alphanumeric LCD display indicating system status and gas concentration level and identified LED's to indicate Power (green), and Alarm Levels A and B (amber);
 - .3 audible alarm rated at minimum 65 dBA at 1 m (3') that will fully activate at programmable levels.
- .3 Loading Dock CO and NO₂ Sensors: Model E3SBSCO and E3SbNo2 remote sensor, 24 volt AC/DC wall mounting enclosure, capable of communicating with a building automation system to monitor exhaust fan status (primary or secondary), zone concentration and alarms through required protocol, and complete with:
 - .1 factory programmed software to enable required sequence of operation;
 - .2 2 internal DPDT relays rated at 5 amperes at 30 VDC, at fully programmable alarm levels and within programmable time delays, and capable of activating remote devices such as fan starters;
 - .3 alphanumeric display indicating exact concentration and type of gas detected, and 2 alarm levels for each sensing point;
 - .4 identified LED's to indicate Power (green), and Alarm Levels A and B (amber);
 - .5 audible alarm rated at minimum 65 dBA at 1 m (3') that will fully activate at programmable levels;
 - .6 continuous monitoring electro-chemical sensors, one for carbon monoxide, one for nitrogen dioxide.
- .4 Digital to Analog Output Convertor: Model 4201 24 volt AC, 500 mA convertor to communicate digitally with up to 8 sensor/transmitter units and control panel within a daisy-chain network to convert digital signal from transmitters to analog outputs to permit each transmitter to produce up to 8 dedicated 4-20 mA signals to a building automation system or variable frequency drive from one central location which can be a maximum of 600 m (2000') from control panel.
- .5 Acceptable manufacturers are:
 - .1 Honeywell Analytics/Vulcain Inc.;
 - .2 Mine Safety Appliance Co. (MSA);

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- .3 Armstrong Monitoring Co.;
- .4 Quatrosense Environmental Ltd. (QEL).
- .7 Double contact switches to monitor equipment status and safety conditions, and generate alarms when a failure or abnormal condition occurs. Status and safety switches are to be as follows:
 - .1 current sensing switches: Veris Industries or approved equal, self-powered dry contact output switches for sensing run status of motor loads, each calibrated to indicate a positive run status only when motor is operating under load, and each consisting of a current transformer, a solid-state current sensing circuit, adjustable trip point, solid-state switch, SPDT relay, and a LED to indicate on or off status;
 - .2 air filter status switches: Johnson Controls Inc. or Cleveland Controls or approved equal, automatic reset type differential pressure switches, each complete with SPDT contacts rated for 2 amperes at 120 VAC, a scale range and differential pressure adjustment appropriate for the service, and an installation kit which includes static pressure taps, tubing, fittings, and air filters;
 - .3 air flow switches: Johnson Controls Inc. or Cleveland Controls or approved equal, pressure flow switches, bellows actuated mercury switch or snap-acting micro-switch type with an appropriate scale range and pressure adjustment;
 - .4 air pressure safety switches: Johnson Controls Inc. or Cleveland Controls or approved equal, manual reset switches, each complete with SPDT contacts rated for 2 amperes at 120 VAC and an appropriate scale range and pressure adjustment;
 - .5 water flow switches: Johnson Controls Inc. Model P74 or approved equal;
 - .6 low temperature limit switches: manual reset type, Johnson Controls Inc. Model A70 or approved equal, each complete with DPST snap acting contacts rated for 16 amperes at 120 VAC, a minimum 4.5 m (15') sensing element for mounting horizontally across duct/plenum with sensing reaction from coldest 450 mm (18") section of element, and where sensing element does not provide full coverage of air stream, additional switches are to be supplied as required.
- .8 Control relays as follows:
 - .1 control pilot relays: Johnson Controls Inc. or Lectro or approved equal, modular plug-in design with snap-mount mounting bases, retaining springs or clips, DPDT, 3 PDT or 4 PDT as required for the application, with contacts rated for 10 amperes at 120 VAC;
 - .2 lighting control relays: latching type with integral status contacts rated for 20 amperes at 120 VAC, each complete with a split low voltage coil that moves the voltage contact armature to On or Off latched position, each controlled by a pulsed tri-state output (preferred) or pulsed paired binary outputs, and each designed so power outages will not result in a change-of-state and so multiple same state commands will simply maintain commanded state.

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- .9 Electronic signal isolation transducers, Advanced Control Technologies or approved equal, for installation whenever analog output signal from building automation system is to be connected to an external control system as an input (i.e. equipment control panel) or is to receive as an input signal from a remote system, and to provide ground plane isolation between systems.
- .10 Each manual override station is to be complete with contacts rated minimum 1 ampere at 24 VAC and is to provide following:
 - .1 integral H-O-A switch to override controlled device pilot relay;
 - .2 status input to building automation system to indicate whenever switch is not in the Auto position;
 - .3 status LED to illuminate whenever output is On;
 - .4 override LED to illuminate whenever H-O-A switch is in either the Hand or Off position.
- .11 Electronic/pneumatic transducers, Johnson Controls Inc. or approved equal, transducers with output of from 3 to 15 psig, an input of from 4 to 20 mA or 10 VDC, manual output adjustment, a pressure gauge, and an external replaceable supply air filter.
- .12 Thermostats:
 - .1 Wall mounting adjustable set-point thermostats, each suitable in all respects for equipment (and operating sequence) they are provided for, equipped with a thermometer, cover and any required mounting and connection accessories.
 - .2 Pneumatic thermostats are to be of bimetal element construction, double valve type, operating without constant waste of air.
 - .3 Low voltage thermostats are to be 24 volt electronic type.
 - .4 Set-point adjustment for thermostats in public spaces is to be concealed behind cover. Set-point adjustment for other thermostats is to be accessible through cover.
 - .5 Covers are to be removable, tamper-proof covers with temperature set-point and thermometer displays.
 - .6 Guards for thermostats are to be clear, ventilated polycarbonate covers with allen key locking hardware.
- .13 Humidistats:
 - .1 Direct or reverse acting (to suit system), proportional type, adjustable humidity controllers, each corrosion resistant, suitable in all respects for application and complete with nylon element, replaceable cartridge type air filter, internally adjustable limit stops for maximum and minimum settings, a cover, and required mounting and connection accessories.
 - .2 Electric humidistats are to be line voltage (115 volt), or 24 volt electronic type.
 - .3 Wall mounting humidistats are to be complete with a tamper-proof display type cover.
 - .4 Duct mounting humidistats are to be complete with a display type cover, duct sampling chamber with 300 mm (12") long extruded pick-up tube for duct mounting, a moulded mounting base, and ventilated cover.

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- .14 Hardware to permit building automation system control and monitoring of input/output points in accordance with Section entitled Building Automation System, points schedule, and drawing control diagrams and operation sequences. Such hardware is to be suitable in all respects for interface with BAS.

2.5 System Wiring Materials

- .1 System wiring, conduit, boxes, and similar materials are to be in accordance with requirements specified in appropriate Section(s) of Electrical Work specification.

PART 3 - EXECUTION

3.1 Demolition

- .1 Perform required control system demolition work.
- .2 Refer to demolition requirements specified in Section entitled Demolition and Revision Work.

3.2 General Re: Installation of Controls

- .1 Provide complete systems of control and instrumentation to control and supervise building equipment and systems in accordance with this Section and drawings.
- .2 Control systems are to generally be as indicated on drawing control diagrams and are to have elements therein indicated or implied.
- .3 Control diagrams show only principal components controlling equipment and systems. Supplement each control system with relays, transformers, sensors, etc., as required to enable each system to perform as specified and to permit proper operation and supervision.
- .4 Brace and secure control system equipment in accordance with requirements specified in Section entitled Seismic Control and Restraint

3.3 Supply of Control Air Dampers and Operators

- .1 Unless otherwise specified, supply required control dampers. Hand dampers to sheet metal trade at site in location where they are required for installation as part of sheet metal work. Ensure each damper is correctly located and mounted.
- .2 Provide linkage and operators for dampers. Wherever possible locate damper operators so they are accessible from outside duct, plenum, and equipment casings. Bracket mount operators on ducts or plenums clear of insulation where applicable.
- .3 Where sequence operation is indicated, or where multiple operators drive a series of dampers, provide pilot positioners to couple their action.
- .4 Ensure dampers located in ductwork other than galvanized steel are constructed of type 316 stainless steel.

3.4 Supply of Automatic Control Valves and Operators

- .1 Unless otherwise specified, supply required automatic control valves. Hand valves to appropriate piping trades at site in locations they are required for installation as part of piping work. Ensure each valve is properly located and installed.

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- .2 Provide operator for each valve.

3.5 Installation of Thermostats

- .1 Unless otherwise noted, provide required thermostats.
- .2 Provide a ventilated clear polycarbonate cover for each thermostat located in finished areas, and a wire type guard for each thermostat located in unfinished areas and in areas such as mechanical rooms where thermostat is subject to damage.
- .3 Unless otherwise indicated, mount room thermostats in accordance with requirements of local governing authority and, where applicable, barrier-free requirements. Review exact location of thermostats with Consultant prior to roughing-in.
- .4 Provide stand-off mounting and an insulated sub-base for thermostats on outside walls.
- .5 Perform control wiring associated with installation of electric or electric-electronic thermostats.

3.6 Installation of Control System Components

- .1 Provide required control system components and related hardware. Refer to drawing control diagrams and sequences.
- .2 Where components are pipe, duct, or equipment mounted supply components at proper time, coordinate installation with appropriate trade, and ensure components are properly located and mounted.

3.7 Installation of Gas Detection System

- .1 Provide gas detection system sensor/transmitter and control panel equipment for areas where indicated and/or specified on drawings.
- .2 Review exact locations of equipment with Consultant prior to installation.
- .3 Perform required 24 volt wiring in conduit to control panel(s) and from each panel to associated sensor/transmitter units as required and in accordance with wiring requirement specified in the electrical work specification and system manufacturer's certified wiring schematics. Provide 24 volt interlock wiring to exhaust fan starters in accordance with drawing control requirements.

3.8 Control Wiring

- .1 Perform required control wiring work for control systems except:
 - .1 power wiring connections to equipment and panels, except as noted below;
 - .2 control wiring associated with mechanical plant equipment and systems whose control is not part of work specified in this Section;
 - .3 starter interlock wiring.
- .2 Except as specified below, install wiring in conduit. Unless otherwise specified, final 600 mm (2') connections to sensors and transmitters, and wherever conduit extends across flexible duct connections is to be liquid-tight flexible conduit.
- .3 Control wiring in ceiling spaces and wall cavities may be plenum rated cable installed without conduit but neatly harnessed, secured, and identified.

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- .4 Wiring work is to be in accordance with certified wiring schematics and instructions, and wiring standards specified in appropriate Sections of Electrical Work Specification.

3.9 Identification and Labelling of Equipment and Circuits

- .1 Refer to identification requirements specified in Section entitled Basic Mechanical Materials and Methods.
- .2 Identify equipment as follows:
 - .1 enclosures and components: engraved laminated nameplates with wording listed and approved prior to manufacture of nameplates;
 - .2 wiring: numbered sleeves or plastic rings at both ends of conductor, with numbering corresponding to conductor identification on shop drawings and "as-built" record drawings.

3.10 Testing, Adjusting, Certification, Start-Up, and Training

- .1 When control work is complete, check installation of components and wiring connections, make any required adjustments, and coordinate adjustments with personnel doing HVAC testing, adjusting and balancing work.
- .2 Refer to Section entitled Basic Mechanical Materials and Methods for equipment/system manufacturer certification requirements.
- .3 Refer to Section entitled Basic Mechanical Materials and Methods for equipment/system start-up requirements.
- .4 Include for 2 full, 8 hour days on-site operation demonstration and training sessions. Training is to be a full review of all components including but not limited to a full operation and maintenance demonstration, with abnormal events.
- .5 Include for 2 follow-up site training and troubleshooting visits, one 6 months after Substantial Completion and other at end of warranty period, both when arranged by Owner and for a full, 8 hour day to provide additional system training as required, and to demonstrate troubleshooting procedures.

END OF SECTION

PART 1 - GENERAL

1.1 Description of Work

- .1 Provide labour, materials, equipment and services necessary for a complete Building Automation System (BAS) comprised of various types of BACnet Testing Laboratories (BTL) listed BACnet-communicating Direct Digital Control (DDC) controllers (referred to as "BAS Controllers"), BTL listed BACnet-communicating operator interface software, conventional electric/electronic controls, and equipment-mounted controls. System is to be fully functional and include software and hardware for specified capabilities.
- .2 Refer to Section entitled Automatic Control Systems for requirements regarding control valves, control dampers, actuators, sensors/transmitters, switches/auxiliary control devices, and other similar field devices.
- .3 Integrate and coordinate controls required by this project into a single system as follows:
 - .1 Each supplier of a controls product is responsible for installation, configuration, programming, start-up and testing of that product unless otherwise stated.
 - .2 Coordinate resolution of any incompatibility issues between BAS products provided under this section and those provided elsewhere in Contract Documents. Equipment/system manufacturer/supplier is responsible for supplying technicians that are to be available to troubleshoot any issues and coordinate with contractor.
 - .3 Be responsible for material and labour to interconnect control products provided by multiple suppliers regardless of where these products are described within Contract Documents.
 - .4 Coordinate to ensure sufficient space and power for BAS components is provided/available.
 - .5 Resolve any conflicts that arise in control of same equipment by both BAS and fire alarm systems. Coordinate with fire alarm system manufacturer and installing contractor to resolve any issues that arise. Fire alarm system control is to be given priority, except where stated otherwise.

1.2 Definitions/Abbreviations

- .1 Advanced Application Controller (AAC) – Fully programmable controller which is BTL-listed as a B-AAC device and which communicates via BACnet MS/TP to an associated network controller (NC). These controllers are used for terminal unit (including VAV boxes) and small AHU/RTU control.
- .2 Application Specific Controller (ASC) – Low-level MS/TP controller typically not custom-programmable and BTL-listed as a B-ASC device.
- .3 BACnet/IP – Use of Ethernet and IP data/network link protocols to transport BACnet messages.

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- .4 B-BC, B-AAC, B-ASC and B-AWS – Abbreviations for BACnet Building Controller, BACnet Advanced Application Controller, BACnet Application Specific Controller, and BACnet Advanced Operator Workstation Software. Used by BACnet standard and BTL to define various device and software profiles, and BACnet functionality to be provided by different classes of DDC devices (for support of interoperability).
- .5 BBMD – BACnet/IP Broadcast Management Device. Method used by BACnet for handling broadcast messages over IP (which does not support broadcasting). Approach involves use of one BACnet/IP device per IP segment to maintain a Broadcast Distribution Table (BDT) listing all other BACnet devices on that network segment. This allows a multi-cast message sent over IP (to each BBMD) to be in turn broadcasted to all other devices on each BACnet/IP segment.
- .6 BTL – BACnet Testing Laboratory. Provides BACnet conformance testing (e.g., to confirm a B-BC device meets minimum requirements for Building Controller profile as defined in BACnet standard). If device passes BTL testing it is said to be "BTL-listed" as, say, a "B-BC device". Devices tested by an ISO accredited laboratory may also issue a certificate, and be referred to as "BTL-certified" device.
- .7 COV (Change of Value) – Optional BACnet service that allows data to be communicated only when it has changed state and/or has changed its value by a pre-defined threshold. This service substantially reduces use of communications bandwidth by BACnet in lieu of using standard "Read" services (which must be polled at regular intervals to ensure changes in values are seen by system).
- .8 FEC – field equipment controller; AAC's and ASC's are field equipment controllers.
- .9 Gateway – Software used to translate one application's protocol data (i.e., BACnet) to another (e.g., Modbus or LonTalk). This software can be installed as a "driver" in a BAS controller (i.e., for Modbus) or provided by a separate gateway device (i.e., for LonTalk) so BAS can connect to "Third Party" devices).
- .10 MS/TP – Master-Slave/Token-Passing, an EIA-485 data link technology unique to and defined by BACnet for transport of BACnet messages.
- .11 NC – Network Controller, highest-level controller in BAS architecture, with B-BC listing, BACnet/IP communications, and routing to/from MS/TP controller sub-networks.
- .12 PICS – Protocol Implementation Conformance Statement, a BACnet form that must be completed for BTL-listing in which device's BACnet device profile (e.g., B-BC), required feature choices (e.g., BACnet/IP vs. MS/TP), and optional features (e.g., COV) are to be documented.

1.3 Submittals

- .1 For each control device submit shop drawings/product data sheets including manufacturer's name, product name and specific model number, options included, product image, proof of BTL listing, dimensions, functional description and operating characteristics, protocol conformance information, and electrical requirements (AC vs. DC, voltage and current draw, or VA).
- .2 Provide system architecture diagram showing communications wiring topology, model number or designation of each communicating device, HVAC or other system/equipment controlled, location and designation of each enclosure containing communicating device, and connections to 3rd party controls.

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- .3 For renovation projects, system architecture is to show complete existing network highlighting where and how new devices are to be added.
- .4 Provide schematic diagram of each controlled system/equipment showing point devices/interfaces with a point naming scheme matching that used on associated control enclosure wiring diagram. Provide a bill of material for devices shown with nomenclature keyed to catalogue data.
- .5 Proprietary services and object types, if used in system, to be thoroughly documented and provided as part of submittal data. Necessary tools to be supplied for working with proprietary information.
- .6 Provide floor plans showing enclosure locations, field devices not mounted in enclosures or on equipment (e.g., space temperature), terminal devices (e.g., VAV box) controller locations, and workstation/server locations.
- .7 Provide enclosure layout and wiring diagram showing BAS controllers, gateways/interfaces to 3rd party controls, enclosure-mounted field devices, internal wiring and wiring to field devices (with wiring tags matching those used on schematic diagrams), a point list with expanded point description information, communications wiring connections, and power supply. Label enclosure devices and key to bill of materials.
- .8 Provide sequence of operation modified and expanded from that provided in this specification to include control details specific to mechanical and controls equipment provided.
- .9 Provide list of data communicated via digital communications interfaces to 3rd party controls (e.g., a chiller or boiler gateway).
 - .1 Prior to completion of submittals, coordinate with 3rd party equipment suppliers to review their documentation and verify data (i.e., BACnet objects and properties, Modbus registers, etc.) required to complete system is available.
 - .2 Prior to completion of submittals, schedule meeting with Consultant to review data lists available for communication to/from 3rd party controls. Based on Consultant's input modify list of data to be communicated from that specified.
- .10 Provide a list of graphic screens, and, for each screen, conceptual layout with points/data to be included and linkages to other screens. Meet with Owner and Consultant prior to submittals to determine their graphic screen format and content preferences.
- .11 Provide, for review, a description of BAS acceptance tests along with forms/checklists to be used during testing.
- .12 Submit a site inspection and start-up report from manufacturer's representative as specified in Part 3 of this Section.

1.4 Quality Assurance

- .1 Electrical installation work is to comply with latest version of local governing electrical code and installed by experienced personnel trained by BAS manufacturer/supplier.
- .2 Provide electrical products which have been tested, listed and labelled by CSA or ULC, and comply with NEMA standards.
- .3 Comply with following codes and standards:

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- .1 UL 916, Energy Management Equipment;
- .2 ASHRAE BACnet Standard 135;
- .3 local governing electrical code.
- .4 Controls Contractor is to provide an experienced project manager (minimum 10 years of related experience) to oversee all aspects of project including design, installation and start-up.
- .5 Anyone involved in design, installation, programming and verification of BAS are to be authorized and trained by BAS manufacturer.

1.5 Warranty

- .1 Provide labour, material and equipment necessary for operation of BAS according to design for a period of 1 year after Substantial Completion of Project. Warranty or final completion service is to be scheduled with Owner to minimize disruptions to facility operations.
- .2 Provide Owner with a telephone number where service representative can be reached at all times. Within 24 hours after receiving a request for service, problem is to be remotely resolved (i.e. via remote communications with BAS) or service personnel are to be at site. Fully restore BAS to proper operating condition within 2 days.

1.6 Acceptable Manufacturers

- .1 Acceptable manufacturers are:
 - .1 Honeywell International Inc.;
 - .2 Johnson Controls Inc.;
 - .3 Siemens Building Technologies;
 - .4 Alerton;
 - .5 Distech.
- .2 Vendors of Alerton and Distech products are to identify on Bid Form, name of installing Contractor representing their respective product. In addition, both vendor and installing Contractor shall provide a minimum of three other projects of equal or greater construction value where these products were installed as part of the building automation system. In addition, provide reference name and contact information for both Owner and Consulting Engineer for the project.
- .3 BAS controllers and operator interface software are to be by one of above manufacturers, except when controls are specified under another section (i.e., referenced as "controls provided with unit," "factory-mounted controls," or "unit manufacturer provided controls," etc. within this section). "BAS Components" includes BAS controllers and operator interface software. Acceptable manufacturers of dampers, valves, actuators, sensors, and other field devices are to be as specified in Section entitled Automatic Control Systems.

PART 2 - PRODUCTS

2.1 Materials

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- .1 Use new products manufacturer is currently manufacturing and selling for use in new installations. Do not use this installation as a product test site unless explicitly approved in writing by Owner. Spare parts are to be available for at least 5 years after completion of this contract.

2.2 BAS Architecture and General Requirements

- .1 BAS using a client server architecture based around a modular PC network, utilizing industry standard operating systems, networks and protocols, and meeting system manufacturer's general requirements.
- .2 BAS is to include, but not be limited to, following:
 - .1 operator workstation to use as primary interface into BAS;
 - .2 custom built graphics including an overview, floor plans, individual graphics for each system, and summary graphics for system comfort and major equipment operation;
 - .3 high speed, peer to peer network of DDC controllers, a control system server, and web-based operator interface;
 - .4 utilize distributed control and not rely on any single controller;
 - .5 software designed around open standards with the control system server being accessible using a web browser over control system network, Owner's LAN or over the internet, and requiring no special software other than web browser to access system information;
 - .6 utilize BACnet protocol for communication to operator workstation, web server and controllers and designed around ANSI/ASHRAE BACnet Standard 135;
 - .7 open system architecture is to allow system to integrate to multiple vendors;
 - .8 capable of future expansion through addition of control devices, DDC controllers and/or operator devices, and is to include capability of 25% expansion.
- .3 Each NC is to have a spare Ethernet/IP port connection for local connection of an operator interface.
- .4 Each BAS controller is to continue to execute its control software, sample input points, and update output points without connection to its BACnet/IP or MS/TP network or an operator interface. If global variables such as OAT are used within a controller's programming/sequence of operation, the global variable is to maintain its last value prior to network disruption.
- .5 .
- .6 Point termination types include:
 - .1 analogue input (AI) - thermistor, 0-10 VDC or 4-20 mA DC;
 - .2 binary input (DI) - monitoring of dry contacts, including contact closure "pulses" up to 10 per second;
 - .3 analogue output (AO) - 0-10 VDC, 0-20 VDC or 4-20 mA DC;
 - .4 binary output (DO) - 2-state DC voltage signal or magnetically held dry contact closure.

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- .7 Each BAS controller is to be able detect a changeover to battery-backed power and modify state of control program, if required by sequence of operation.
- .8 Upon reestablishment of power to a BAS controller, devices are to return to normal operation in less than one minute.
- .9 Server computer and operator workstation hardware capable of interfacing to an IEEE 802.3 Standard Local Area Network (LAN), and also capable to operate using IEEE 802.11 Wireless Local Area Network (WLAN).
- .10 Digital Communications to 3rd Party Controls
 - .1 BAS is required to send/receive information via digital communications technologies (i.e. Ethernet/IP, or EIA-485) and application protocols (i.e., BACnet, or Modbus) to specified "3rd Party" controls provided under other sections of this specification (e.g., VFD's, Chillers, etc.).
 - .2 Refer to specification sections of equipment involved (e.g., VFD, Chiller, etc. section) for type of communications technology/interface (e.g., data link layer protocol) and application protocol used by each of 3rd Party controls, and for list of data to be shared with these controls.
 - .3 Communications not requiring a BAS Gateway (i.e., BACnet) - Design BAS to include NC's and sufficient EIA-485 communications ports (for MS/TP) to support communications and data handling capacities required.
 - .4 Communications Requiring a Network Controller "Driver" (e.g., Modbus) - Design BAS to include NC's and sufficient EIA-485 communications ports (for Modbus-RTU), and any optional software "drivers" and/or hardware if necessary to support communications technology and application protocol gateway interfaces.
 - .5 Communications Requiring a Gateway (e.g., LonTalk) - Design BAS to include sufficient BACnet/IP-communicating devices, with sufficient LonTalk communications capacity to support LonTalk 3rd Party devices.
- .11 System is to perform following general functions:
 - .1 building management and control;
 - .2 monitoring and control of controllers, remote devices and programmable logic controllers including sensors, actuators, environmental delivery systems (chillers, boilers, room climate control, lighting systems, electrical systems etc.);
 - .3 operator interface to allow general supervision of room controls;
 - .4 video display integration;
 - .5 data collection and historization;
 - .6 alarm management;
 - .7 trending;
 - .8 report generation;
 - .9 network integration;
 - .10 controller scheduling;

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- .11 data exchange and integration with a diverse range of other computing and facilities systems using industry standard techniques.
- .12 In event of a power failure or disconnection from BAS, controllers are to continue to be fully operational with full time program capability.

2.3 Network Controller (NC)

- .1 NC is a BTL listed BACnet B-BC device in accordance with following requirements:
 - .1 non-volatile memory for operating system software;
 - .2 read/write memory for custom control programming, trending, and alarming;
 - .3 real time clock;
 - .4 integral point or point expansion terminations;
 - .5 communications support to other NC's;
 - .6 minimum Quad Core 996Ghz processor;
 - .7 global control algorithms and automated control functions to execute using a 64-bit processor;
 - .8 minimum of 1 GB of DDR3 SDRAM on a 533Mhz bus;
 - .9 EIA-485 ports capable of supporting various EIA-485 protocols including, but not limited to BACnet MS/TP and Modbus;
 - .10 provide normal seven-day scheduling, holiday scheduling and event scheduling;
 - .11 logging capabilities for any object type with sample time interval adjustable at operator workstation;
 - .12 alarm generation for any object change of value or state;
 - .13 built-in, user-configurable demand limiting of energy.
- .2 Each BACnet MS/TP LAN to support a minimum of 50 BACnet devices.
- .3 NC Communications Network: 100baseT Ethernet minimum communications with BACnet/IP support for interconnection to other NC's, operator interfaces, and to an Internet/Intranet connection, if specified.
- .4 Web-Server: Password-protected access directly to controller to view, diagnose and modify operating features/parameters using a web browser with factory provided web pages used for this capability that require no setup other than required for programming controller.
- .5 NC is to provide:
 - .1 Communications support as "master" to up to 3 separate 76.8Kbps minimum BACnet MS/TP data link layer communications connections for advanced application and application specific controllers.
 - .2 BACnet Clause 6 Routing (between specified NC's and controller network technologies) and BACnet/IP Broadcast Management (BBMD).
- .6 NC is to be of scalable design such that number of trunks and protocols may be selected to fit specific requirements of a given project.

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- .7 Controller to be capable of running up to six independent control strategies simultaneously. Modification of one control strategy does not interrupt function or runtime others.
- .8 Controllers for critical applications are to be B-BC controllers with IP connectivity.

2.4 Field Equipment Controllers (FEC)

- .1 Advanced Application Controller (AAC)
 - .1 BTL listed BACnet B-AAC device with:
 - .1 non-volatile memory for operating system software;
 - .2 read/write memory for custom programming;
 - .3 76.8Kbps minimum BACnet MS/TP communications;
 - .4 direct point termination through integral point connections;
 - .5 communications support for operator interface and controller network.
 - .2 Application controllers to include universal inputs with 12-bit resolution that accept 3K and 10K thermistors, 0–10VDC, Platinum 1000 ohm RTD, 0–5VDC, 4–20mA and dry contact signals. Any input on a controller may be either analog or digital with a minimum of three inputs that accept pulses. Controller to include binary and analog outputs on board. Analog outputs with 12-bit resolution to support either 0–10VDC or 0–20mA. Binary outputs to have LED indication of status. Software to include scaling features for analog outputs. Application controller to include 20VDC voltage supply for use as power supply to external sensors.
 - .3 Controller to also include support and modifiable programming for interface to intelligent room sensor with digital display.
 - .4 All program sequences to be stored on board application controller in EEPROM. No batteries are to be needed to retain logic program. Program sequences to be executed by controller up to 20 times per second (minimum of 10 times per second) and capable of multiple PID loops for control of multiple devices. Calculations to be completed using floating-point math and system to support display of all information in floating-point nomenclature at operator's terminal.
 - .5 Programming of application controller to be completely modifiable in field over installed BACnet LANs or remotely using modem interface.
- .2 Application Specific Controller (ASC)
 - .1 BTL listed BACnet B-ASC device dedicated for use with specific equipment and applications, and provided with:
 - .1 non-volatile memory for operating system software;
 - .2 read/write memory for all other purposes;
 - .3 factory-provided control software;
 - .4 76.8Kbps minimum BACnet MS/TP controller network connection (as an MS/TP master);
 - .5 integral point termination;

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- .6 communications support for operator interface, and controller network.
- .2 Application controllers to include universal inputs with 10-bit resolution that can accept 3K and 10K thermistors, 0–5 VDC, and dry contact signals. Inputs on controller may be either analog or digital. Controller to also include binary outputs on board. For applications using variable speed parallel fans, provide a single analog output selectable for 0-10 V or 0-20 mA control signals. Application controller to include microprocessor driven flow sensor for use in pressure independent control logic. All boxes to be controlled using pressure-independent control algorithms and all flow readings to be in LPS (CFM).
- .3 Controller to also include support and modifiable programming for interface to intelligent room sensor with digital display.
- .4 Program sequences to be stored on board application controller in EEPROM. No batteries are to be needed to retain logic program. Program sequences to be executed by controller 10 times per second and be capable of multiple PID loops for control of multiple devices. Programming of application controller to be completely modifiable in field over installed BACnet LANs or remotely using modem interface. Operator to program logic sequences by graphically moving function blocks on screen and tying blocks together on screen. Application controller to be programmed using same programming tool as Building Controller and as described in operator's workstation section. Programming tools to be provided as part of system.
- .5 Do not use application specific controllers for systems/equipment that require custom application programming to meet sequence of operation (i.e., if an application specific controller is used, factory-provided control software/program is to perform sequence of operation without "upper level" control from another BAS controller).
- .6 Include an integral differential pressure sensor for controllers used for air flow measurement and an optionally integral damper actuator.
- .3 FEC's for terminal units to be provided by terminal unit manufacturer.
 - .1 All calibration parameters are to be adjustable through intelligent room sensor.

2.5 Distributed System Servers

- .1 Method for monitoring and control of points on remote BAS servers, specifically, real-time and history values. Features supported include:
 - .1 Global access to data, such that users at operator workstations on one server can access data, history, point detail displays, etc. for points on any other server. It is not to be necessary to configure system wide, more than one point for each data value or signal, regardless of number of servers accessing data.
 - .2 Ability to nominate sets of points to be accessed on a server-by-server and user-by-user basis. Mechanism is to be same as mechanism to control individual operator and workstation access to data for single server systems.
 - .3 Operators and workstations at any server are to see alarms from any other server, and not necessary to configure alarms more than once, regardless of number of servers accessing data.

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- .4 Ability to configure real time and historical trends that combine data from any connected server on a single trend, and not necessary to configure more than one point for each data value or signal, regardless of number of servers accessing data.
- .5 Graphics, reports, and applications at a server have same distributed access to data on other servers as described above for operators and workstations, and not necessary to configure more than one point for each data value or signal, regardless of number of servers accessing data.
- .6 Important service oriented architecture (SoA) web services enabling extension of BAS system providing seamless access to points, alarms and history from any distributed system server, without needing to directly address each individual server. Data across distributed system servers is to be seamlessly integrated into Web services.
- .2 System to support identical point names on any of the connected servers in distributed system. With exception of scope of responsibility assignment, there is to be no engineering effort to connect these distributed systems.
- .3 Connections between servers can be made through local Ethernet connections, plant's LAN, or corporate WAN. Connections are optionally redundant. Both redundant and non-redundant servers must be supported, and no additional engineering effort is to be required to connect both kinds of servers.
- .1 ULC listed server computer platform is to be used when ULC compliant system is required.
- .4 System capable of supporting up to 80 simultaneous operator workstation connections using a TCP/IP LAN, and network connection allowing a limitless number of casual users access to the 80 connections on a first-come-first-served basis.
- .5 Operator workstation is to be approved by BTL as meeting BACnet Advanced Work Station requirements. Operator's workstation is to comply with Annex J of BACnet specification for IP connections.

2.6 Operator Interface

.1

2.7 Open Integration

- .1 Any of following Open Protocol Standards is to be used as necessary for integration of 3rd party devices or systems.
- .2 Modbus
 - .1 Include an integrated interface to devices using Modbus RTU protocol, where BAS server is to be 'master' and external device or system is to be "slave".
 - .2 Support user definable data formats for Modbus devices to accommodate wide variety of formats in use in industry.
- .3 BACnet (ANSI/ASHRAE 135)

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- .1 Capable of communicating to other building subsystems using ASHRAE standard BACnet, and capable of acting as both a BACnet operator workstation and a BACnet gateway and support various standard BACnet objects.
- .4 BACnet Operator Workstation
 - .1 Integrated BACnet operator workstation allowing monitoring of BACnet devices via data acquisition and control.
 - .2 BACnet operator workstation is to support various BACnet Interoperability Building Blocks.
- .5 BACnet Gateway
 - .1 Integrated BACnet gateway allowing 3rd party BACnet clients to access data.
 - .2 BACnet gateway is to support various BACnet Interoperability Building Blocks.
- .6 OLE for Process Control (OPC)
 - .1 Include an integrated OPC Client, integrated OPC Data Access Server, and OPC Alarm and Event Server.
- .7 Data Exchange
 - .1 Capability to interface to point database of other BAS systems (i.e. nodes) on a TCP/IP network enabling both acquiring of point data and issuing control outputs to and from connected BAS systems.
- .8 Data Exchange with Microsoft Excel
 - .1 Capable of exporting bulk data to Microsoft Excel.

2.8 Wiring Materials

- .1 System wiring, conduit, boxes, and similar materials are to be in accordance with requirements specified in the appropriate Section(s) of the Electrical Work Division of the Specification.

2.9 Enclosures

- .1 NEMA rated appropriate for location of equipment, for BAS components including controllers, sensors and other devices except space sensors. Refer to Section entitled Automatic Control Systems for additional requirements regarding local control panels.

PART 3 - EXECUTION

3.1 General Installation Requirements

- .1 Provide a complete building automation system in accordance with requirements of this Section, Section entitled Automatic Control Systems, drawings, and input/output points list(s).
- .2 Install BAS components and materials in accordance with manufacturer's instructions. Where drawings conflict with these instructions, submit a written request for clarification.
- .3 Coordinate installation with other trades to avoid field condition conflicts.
- .4 Electrical products and execution are to comply with requirements of applicable Electrical Division Sections.

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- .5 Provide necessary quantities of NC's to meet project requirements and connect NC's together using a BACnet/IP network. Provide sufficient number of NC's to support number of FEC's.
- .6 Comply with system manufacturer's instructions with regards to maximum number of devices to be connected to a power or control circuit.
- .7 Connect operator interface PC installed on project site to BAS via BACnet/IP.
- .8 Provide and connect FEC's to NC's via BACnet MS/TP.
 - .1 To minimize number of mechanical systems that would be inoperative in event of FEC failure, a maximum of 1 major mechanical system is to be controlled by one FEC.
 - .2 FEC's for equipment (e.g., VAV boxes, VFD's, etc.) are to be connected to same NC used to control associated equipment/system (i.e., AHU, chiller plant, etc.).
 - .3 Failure of a single controller is not to result in system-wide failure.
- .9 Surface wall mount NC and FEC control units in Mechanical Rooms ensuring they are not mounted on vibrating surfaces, and connect to 15A-1P circuit breakers dedicated for control system applications, in branch panel circuit boards in adjacent spaces. Power wiring from control units to circuit breakers is to be responsibility of controls contractor. Wiring is to be in conduit, and conduit and wiring are to be in accordance with standards and requirements of Electrical Division work Sections. Refer to electrical drawings for locations of branch circuit panelboards with dedicated circuits for controls system applications.
- .10 Extend and connect wiring in conduit from terminal unit box actuators and connect to 15A-1P circuit breakers dedicated for terminal unit box applications, in branch circuit panelboards in adjacent spaces. Wiring is to be in conduit, and conduits and wiring are to be in accordance with standards and requirements of Electrical Division. Refer to electrical drawings for locations of branch circuit panelboards with dedicated circuits for controls system applications. No more than 15 terminal unit box circuits are to be connected to one dedicated circuit breaker.
- .11 Provide 120 volt/24 volt transformers as required for control devices.
- .12 Submit schedule(s) of input/output points to Consultant for review. Directly connect each NC and FEC to point devices in accordance with control diagrams and schedule of miscellaneous control points as shown on drawings. Sensor wires for each analogue input are to be No. 18 AWG twisted shielded cable. Other types of wire required are to be as recommended by system supplier.
- .13 Supply and turn over to Consultant prior to application for a Certificate of Substantial Performance of the Work, reports to be used in assisting Owner in defining and debugging DDC programs. These reports are to consist, as a minimum, of following:
 - .1 process control language (PCL) logs;
 - .2 control loop logs;
 - .3 PCL master point.
- .14 Submit Point Data Input forms to Consultant that Owner will fill out with DDC system supplier's assistance. Input this point data into system.

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- .15 Contacts will be supplied as part of mechanical work or electrical work for alarm and status points for systems and equipment other than building environmental systems and equipment. Connect to DDC system in accordance with point schedule.
- .16 Indicate via number, systems controlled by NC and FEC. Indicate via a Lamacoid label mounted inside panel the identification number of electrical panel supplying power to NC and FEC.
- .17 Meet with Owner and provide required number of hours of field work dedicated to following:
 - .1 developing custom dashboards/graphics;
 - .2 setting up time schedules and optimal start/stop programs;
 - .3 setting up alarms including method for monitoring, annunciating and handling of alarms;
 - .4 setting up trends including establishing and storing trend information for systems as required;
 - .5 ensuring all demand limiting and energy conservation strategies are set up according to Owner's energy plan (if applicable).

3.2 Supply of Actuators and Controllers for Terminal Units

- .1 Supply required 24 volt actuators and controllers for terminal units.
- .2 Deliver actuators and controllers to successful terminal unit manufacturer's factory.
- .3 Coordinate delivery of product with General Contractor and successful terminal unit manufacturer.

3.3 Implementation of Energy Management Programs

3.4 Control Wiring and Communications Cabling

- .1 Perform required control wiring work for control systems except:
 - .1 power wiring connections to equipment and panels, except as noted below;
 - .2 control wiring associated with mechanical plant equipment and systems whose control is not part of the work specified in this Section;
 - .3 starter interlock wiring.
- .2 Install control wiring in EMT in exposed or concealed, inaccessible locations. ULC plenum rated FT6 cable is acceptable for concealed, accessible locations, neatly harnessed, secured and identified. Unless otherwise specified, final 600 mm (2') connection to sensors and transmitters, and wherever conduit extends across flexible duct connections is to be liquid-tight flexible conduit.
- .3 Field devices provided with pig-tail wiring without any integral means of flexible metal raceway attachment are to be enclosed with a suitable means to allow for flexible metal raceway attachment.
- .4 Install parallel to building lines, supported from structural members. Raceway or plenum wiring supported from or anchored to piping, duct supports (raceway only), ceiling suspension system (raceway only), or other electrical conduits is not acceptable.

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- .5 Use flexible metal raceway, not in excess of 0.9 m (3') in length, for termination of raceway on vibrating equipment. Support flexible metal raceway at each end.
- .6 Use shielded wiring where recommended by manufacturer and install in accordance with manufacturer's instructions.
- .7 Install communications wiring as continuous lengths with no splices between termination points.
- .8 Provide Ethernet/IP communications wiring and devices (hubs, repeaters, etc.) for dedicated use by BAS.
- .9 Wiring work is to be in accordance with BAS manufacturer's certified wiring schematics and instructions, and wiring standards specified in Electrical Division Specification.
- .10 Provide additional communications bus as required complete with required ancillaries. Connect and extend existing communications bus.
- .11 Provide control wiring for water meters, gas meters, etc., as applicable, and connect to BAS for meter data integration.

3.5 Installation of Enclosures

- .1 Provide NEMA rated enclosures, and coordinate enclosure locations with other trades and show in submittals.

3.6 Identification and Labelling

- .1 Refer to Section entitled Basic Mechanical Materials and Methods.
- .2 Identify BAS equipment as follows:
 - .1 enclosures and other devices mounted in field: engraved laminated nameplates with lettering such as "BAS Panel CP2", or "BAS Relays", or "BAS E/P Transformers", with all wording listed and reviewed with Consultant prior to manufacture of nameplates;
 - .2 panel points: weatherproof input/output layout sheet for each controller with name of each point connected to controller, and associated wire labelling information;
 - .3 wiring: numbered sleeves or plastic rings at both ends of conductor, with numbering corresponding to conductor identification on shop drawings and "as-built" record drawings;
 - .4 interface components: weatherproof layout sheet clearly illustrating/identifying purpose of each component within enclosure such that an operator or service technician can quickly identify exact use of each relay, transducer, contactor, etc., with each sheet fastened securely to back of enclosure door.

3.7 Software Set-up, Configuration and Programming

- .1 Provide data base entry, software configuration, initialization of trends and alarms, and custom application programming to meet this specification.
- .2 Set-points, PID tuning parameters, control deadbands, operating differentials, reset schedules, etc. are to be adjustable by an operator without need for accessing/modifying custom control programming code.

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- .3 Coordinate number of users, user passwords and user authority profiles with Owner.
- .4 Provide following control software in addition to that described in sequence of operation (where applicable):
 - .1 PID Control: Each control loop is to be controlled by a PID (proportional-integral-derivative) algorithm. Loop is to be tuned using P and I gains as a minimum.
 - .2 Reset: Unless otherwise noted, any set-point required to be reset is to use a cascaded PID loop or an "every x minutes increment/decrement by y" algorithm. Contractor to tune these reset loops to provide stable control.
 - .3 Anti-Short Cycling: AO and DO points are to be protected from short cycling allowing minimum on-time and off-time to be selected. Unless otherwise noted, motors are to be limited to 4 starts per hour (1 per hour for a chiller, 6 for cooling tower fans).
 - .4 Optimum Start: Air handlers that do not operate continuously are to be optimally started at latest possible time to meet occupied conditions at time of occupancy. Utilize space temperature inputs associated with air handler, along with outside air temperature. Algorithm is to include tuning parameters for adjusting influence of space and outside air temperature on start time.
 - .1 Warm-up Mode -Optimally started AHU is to operate in warm-up mode until occupancy. Outside air damper(s) close and return air dampers open. If AHU supplies multiple zones (e.g., VAV boxes), supply air temperature is to be space temperature set-point (adjustable).
 - .2 Night Setback - When not in occupied or warm-up modes an AHU is to cycle on to maintain a night setback temperature of 15°C (60°F) (adjustable) if AHU supplies a single zone or if zones that cannot provide heating without operation of AHU (pinch-down VAV boxes with reheat coils).
 - .5 Alarm Communications: BAS' alarm/event communications features are to be set up to automatically initiate IP-based alarm/event communications (i.e., to pagers, mobile phones, email, alarm printers, etc.) for selected alarms/events. Consult with Owner to determine what communications method(s) is required, communications devices involved, and what alarm conditions/priority/time-of-day are to initiate these communications.
- .5 Point names, schedules, and space temperature set-points are to be chosen to meet approval of Owner (even if specified herein). Submit to Consultant for review.
- .6 Set up logs (including trended points/data, frequency and number of samples) and alarmed points (including alarm limits, alarm messages, alarm message destination email, phone, printer, etc. addresses; and alarm message transmission formats to be used) to meet approval of Owner (consult with Owner and review with Consultant).
 - .1 As a minimum system is to trend all process variables, setpoints, output devices and equipment statuses for each system.
 - .2 Trend intervals (adjustable) are as follows:
 - .1 space temperature/humidity – 15 minutes;
 - .2 duct sensor – 1 minute;
 - .3 pressure sensor – 1 minute;

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- .4 outdoor sensor – 15 minutes;
- .5 actuators – 1 minute;
- .6 binary I/O – on COV;
- .7 setpoints – on COV or with reading as above.
- .7 Only one NC's BACnet BBMD (broadcast messaging management) capability is to be enabled per IP subnet and configured with list of peer BBMD's and its subnet's devices.
- .8 Duct static pressure set points for VAV air handling units are to be selected based on coordination with TAB agency to provide design air flows.
- .9 Coordinate duct differential pressure high/low limit setting values with TAB agency.
- .10 Pipe static pressure set points for variable pumping systems are to be initially selected based on scheduled pressure drop(s) of coils at which static pressure sensor(s) is installed. Final selection is to be based on coordination with TAB agency to provide design water flows.

3.8 Data Control (D/C) and Graphics Summary

- .1 Provide hardware, custom software, application software, graphics, etc., necessary to accomplish control sequences and display graphics specified. Provide controllers, inputs, outputs, valves, dampers, actuators and flow meters required to provide control and graphic data described. Provide software set-points required for display in logical groups and graphics.
- .2 Each digital output is to have a software-associated monitored input. Any time monitored input does not track its associated command output within a programmable time interval, a "command failed" alarm is to be reported.
- .3 Where calculated points (such as CFM) are shown, they are to appear in their respective logical groups.
- .4 Unless otherwise specified or approved prior to bidding, primary analogue input and analogue output of each DDC loop is to be resident in a single remote panel containing DDC algorithm, and are to function independent of any primary or UC communication links. Secondary (reset type) analogue inputs may be received from primary network, but approved default values and/or procedures are to be substituted in DDC algorithm for this secondary input if network communications fail or if secondary input becomes erroneous or invalid.
- .5 In addition to unitary DDC controller data points specified to be presented on colour graphic displays, technical data for each zone mechanical apparatus is to be presented to operators on operator workstation in full English menu text displays including:
 - .1 apparatus name;
 - .2 heating and cooling PID loop P, I and D gains;
 - .3 primary CFM airflow (if measured);
 - .4 damper position (% open);
 - .5 reheat status/value;
 - .6 cooling set-point;

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- .7 heating dead-band;
- .8 minimum and maximum CFM set-points;
- .9 reheat CFM set-point;
- .10 unoccupied temperature set-point;
- .11 temperature sensor calibration offset;
- .12 morning warm-up mode damper position.
- .6 Such points are to be presented in complete and direct read-write (command) format, unless they are provided in commandable colour graphic displays.
- .7 Following additional graphics are to be provided:
 - .1 facility layout (showing buildings, streets, etc.);
 - .2 individual area layouts or isometrics;
 - .3 any other graphics necessary for logical penetration;
 - .4 individual HVAC systems graphics;
 - .5 facility/area layouts including alarm icon indicating which room has alarm;
 - .6 alarms displayed in alarm console linked to facility/area layout graphics to show where on layout alarm has occurred;
 - .7 sequences of operation;
 - .8 supervisor graphics;
 - .9 system configuration.
- .8 Graphic templates of each system and graphics page to be reviewed by Consultant and approved by Owner, prior to installation and start-up.

3.9 Application Requirements

- .1 Software - Microprocessor-based control system is to rely on software for non-critical interlocks and time delays. Where required by specifications, these functions are to be provided by separate thermostats, relays, and delay timers.
- .2 Interlocks - Safety and other interlocks may require relays depending on specific devices being used. Some devices may require a special power supply as shown in wiring details. Safeties are to be hardwired into control circuit and also monitored by BAS.
- .3 Sensors - Select duct insertion sensors to suit application. For large ducts, use sensors with longer probe lengths. For heating and cooling coil freeze protection, use a long capillary type sensor. For mixed air and coil discharge temperature sensing, use averaging capillary type sensors.
- .4 Valves - Ensure actuators meet job requirements (i.e., control signal, close off, action, etc.). Control valves are to be selected to suit both medium and specified configuration (i.e., straight-thru, 3-way, screwed, flanged, etc.).
- .5 Damper Actuators - Total number of actuators may vary depending on damper size. Consult actuator's application literature to determine sizing requirements and use no less than 30% of minimum number of actuators recommended.

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- .6 Graphics - System graphics are to include operator control panels to facilitate working with AHUs such as:
 - .1 Warm-up Panel is to permit operator to monitor status of warm-up mode (on or off), and to change set-point of warm-up temperature.
 - .2 Unoccupied Cycle control panel is to permit operator to monitor status of mode (occupied or unoccupied), and to change unoccupied periods set-points.
 - .3 Mixed Air Dampers control panel is to permit operator to monitor economizer mode (on or off), monitor damper position, and to change minimum position set-point.
 - .4 Optimum Start/Stop control panel is to permit operator to monitor and change optimum start/stop program parameters.
 - .5 Reset Schedule control panel is to permit operator to monitor and change reset schedule program parameters. It is not acceptable to monitor and change these modes of control in a manner other than that specified. Having to edit, compile and reload application programs to achieve monitoring and control of these modes is not acceptable.
 - .6 Provide text of control sequence so it may be displayed on operator screen by clicking on sequence control button on system graphic. Sequence will incorporate parameter values and set-points, and will update them dynamically as they change or are changed.

3.10 System Performance Requirements

- .1 Installed system is to conform to following minimum performance standards:
 - .1 Graphic with 20 dynamic points is to display current data within 10 seconds.
 - .2 Graphic with 20 dynamic points is to refresh every 15 seconds.
 - .3 Screens for tuning are to refresh every 6 seconds.
 - .4 Commands from operator interface to device are to take no longer than 5 seconds.
 - .5 Alarms are to annunciate at workstation within 45 seconds.
 - .6 Field level controllers are to execute PID loops at a response time suitable for application with capability of executing once per second.
 - .7 Loop stability:
 - .1 Space temperature to be maintained within $\pm 1^{\circ}\text{C}$ of set-point.
 - .2 Return air humidity to be maintained within $\pm 5\%$ RH of set-point.
 - .3 Duct pressure to be maintained within ± 50 Pa of set-point.
 - .4 Fluid differential pressure to be maintained within ± 250 Pa of set-point.
 - .5 Air volume to be maintained within $\pm 10\%$ of set-point.

3.11 Sequences of Operation and BAS Points

- .1 Refer to mechanical drawings for control diagrams and sequences.

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- .2 Points – Points as shown on mechanical drawings are to be considered minimum. Provide points and point types required to meet sequence of operation.
- .3 DDC Sequence for Manually Started Equipment – Unless noted otherwise, when an operator starts main component (e.g., fan, boiler, chiller, etc.) of an HVAC system (e.g., AHU, hot water plant, chiller plant, etc.) by a manual method outside of BAS (e.g., a motor starter H-O-A), BAS will execute described system (based on sensing motor operation via status input).
- .4 Safeties – Safety sequences for high or low temperature reactions are not to be implemented by "software interlocks". Automatic resets of safeties will not be accepted.

3.12 System Testing and Acceptance

- .1 Perform BAS acceptance testing in presence of Owner or Owner-designated representative. System is to not be considered substantially complete until testing is complete and accepted. Perform calibration, start-up and testing procedures necessary to assure completion of system acceptance testing prior to commencement of system acceptance tests.
- .2 Point Tests
 - .1 Perform following tests for each point:
 - .1 Analog Input - Compare sensor reading to that of a calibrated portable measurement device.
 - .2 Binary Input - Manually actuate monitored equipment and compare actual state with that read by system.
 - .3 Analog Output - Through software, set output to 3 or more values across full range of actuation and compare with position of controlled device (or output signal for controlled device positions that cannot be visually observed).
 - .4 Binary Output - Through software, actuate output and compare control command with actual operation of controlled device.
 - .5 Data (from digital communications with "3rd party controls") - Perform above tests, though comparison (except for data representing binary outputs) between that provided at 3rd party controller display and BAS. Perform above "Binary Output" test for data that represents digital outputs.
- .3 System Tests
 - .1 Perform following tests for sequences of operation:
 - .1 Demonstrate DDC loop response. Contractor is to supply trend data output in a graphical form showing step response of each DDC loop. Test is to show loop's response to a change in set-point, which represents a change of actuator position of at least 25% of its full range. Sampling rate of trend is to be from 10 seconds to 3 minutes, depending on speed of loop. For each sample, trend data is to show set-point, actuator position, and controlled variable values. Any loop that yields unreasonably under-damped or over-damped control is to require further tuning by Contractor.
 - .2 Simulate loop (i.e. change set-points) to verify reset schedules and temperature lockouts.

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- .3 Manually initiate system start-ups to verify interlocks and sequencing.
 - .4 Simulate safety device and fire alarm system contact actuation to verify emergency, alarm, and life safety sequences.
 - .5 Simulate day/night changeover to observe occupied, unoccupied, optimum start, and warm-up modes.
 - .6 Simulate seasonal changeovers to observe proper operation of heating and cooling modes.
- .4 In addition, arrange for control system manufacturer to supply at site, qualified control system technicians to make adjustments to control systems to suit air and water balancing and testing.

3.13 Certification, Start-Up and Training

- .1 Refer to Section entitled Basic Mechanical Materials and Methods for equipment/system manufacturer certification requirements.
- .2 Refer to Section entitled Basic Mechanical Materials and Methods for equipment/system start-up requirements.
- .3 Include for demonstration and training sessions for each of 2 groups of Owner's operating and maintenance personnel as follows:
 - .1 3 full, 8 hour, day orientation sessions at system manufacturer's office to educate personnel on BAS architecture, hardware, and software, with an overview of BAS operation and capabilities including but not limited to operational programmes, equipment functions (both individually and as part of a total integrated system), BAS commands, advisories, alarms, and appropriate operator intervention required in responding to BAS operation;
 - .2 2 full, 8 hour, day sessions at site using BAS for a "hands-on" demonstration of all BAS functions and features with instruction regarding chronological flow of information from field devices, contacts and sensors to the operator's workstation, an overview of communications network describing interplay between initiating devices, field hardware panels, systems communications, and their importance within operating BAS, and alarm indications and appropriate responses;
 - .3 2 full, 8 hour, day seasonal (summer-winter) site sessions to perform additional instruction regarding seasonal changes and how they affect BAS.
- .4 Include for 2 follow-up site training and troubleshooting visits, one 6 months after Substantial Completion and other at end of warranty period, both when arranged by Owner and for a full, 8 hour, day to provide additional system training and troubleshooting as required.

3.14 Project Closeout Work

- .1 Include following in as-built record drawings at a minimum:
 - .1 schematic outline of BAS for quick reference of overall system scope;
 - .2 adequate record of Work as installed, including its exact location and wiring and route;

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- .3 adequate record of existing controls retained and/or interfaced, including its exact location and wiring, tubing, etc., route.
- .2 Include following in O&M manual at a minimum:
 - .1 as-built versions of manufacturer's product data with list of equipment supplied, including its make, model number, name of local suppliers and quantity;
 - .2 complete network architecture indicating all network addresses, communication protocols, controllers, controller locations, and equipment controller by each controller;
 - .3 for renovation projects, indicate entire existing system network and clearly show new network devices added to network;
 - .4 maintenance information for all devices;
 - .5 operator's manual including detailed instructions for operations of BAS;
 - .6 programmer's manual including information necessary to perform programming functions;
 - .7 system hardware specification manual, which provides a functional description of all hardware components;
 - .8 system operator's manual which provides concise instructions for operation of the system and an explanation and recovery route for all system alarms;
 - .9 system engineering manual which provides information for system set-up, definition and application;
 - .10 complete project-specific graphic screens, custom sequence programming, system databases, parameter listings, etc. for equipment controlled under this phase of work (backed up to operator interface or web server and onto CD/DVD's);
 - .11 copy of warranty;
 - .12 operating and maintenance cautions and instructions;
 - .13 log-in requirements, information, and/or instructions (including any hardware key(s) or software licensing documentation) to allow Owner access (for both viewing and modification) to system set-up databases, custom programming, service software, etc. at highest user level provided by manufacturer;
 - .14 recommended spare parts list;
 - .15 original issue documentation and software DVD's/CD's (if applicable) for 3rd party hardware and software;
 - .16 completed BAS test forms/checklists.

3.15 Controls Contractor's Responsibilities

- .1 Comply with applicable responsibilities specified in this Section and below:
 - .1 provide and pull power wire to controllers;
 - .2 provide start-up, test procedures and O&M manual;
 - .3 provide print out and electronic copy of all points connected to BAS;

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- .4 provide detailed consolidated wiring diagram showing interface of BAS controls with packaged controls;
- .5 responsible for component and point to point testing;
- .6 responsible for sensor calibration and actuator adjustment;
- .7 provide calibration procedure for each analogue sensor;
- .8 operate systems during testing;
- .9 provide training and instruction;
- .10 responsible for acceptance test for a 21 day period;
- .11 set-up trend logs and group logs which are to be stored on hard disk;
- .12 re-visit site during first year of operation to review BAS performance as detailed in this Section in article entitled Certification, Start-Up and Training;
- .13 any other controls requirements specified in Contract Documents.

END OF SECTION