

MONTGOMERY SISAM ARCHITECTS INC.

KAHLER SLATER

**UNIVERSITY OF TORONTO
DENTISTRY BUILDING – CLINIC 2 RENOVATION**

124 EDWARD ST
TORONTO, ON M5G 1G6

**PROJECT MANUAL
VOLUME 2 of 3**

UofT Project No. P065-21-050
MSA Project No. 24082

SPECIFICATIONS

Divisions 20 to 33

ISSUED FOR TENDER

May 29th, 2026

Entuitive
Structural

EXP Services Inc.
Mechanical / Electrical / IT / Sustainability

LRI Engineering Inc.
Building Code / Life Safety

Soberman Engineering Inc.
Elevator Consultant

Thornton Tomasetti
Acoustic Consultant

Allegion
Hardware Consultant

Oktus Development Inc.
Logistics Consultant

Design Discipline

Documents prepared by the respective Consultants are designated by the following discipline symbols:

- Owner (O)
- Architect (A)
- Electrical Consultant (E)
- Elevator Consultant (ELEV)
- Hardware Consultant (H)
- Mechanical Consultant (M)
- Structural Consultant (S)
- Sustainability Consultant (SUS)

VOLUME 2

(Divisions 20-33)

DIVISION 00 - PROCUREMENT AND CONTRACTING REQUIREMENTS

Document	Title	Discipline	Pages
	Cover Page	A	1
00 01 10	Table of Contents (Volume 2)	A	4

DIVISION 20 - MECHANICAL, GENERAL

Section	Title	Discipline	Pages
20 05 05	Common Work Results for Mechanical	M	31
	- Transfer of Files on Electronic Media	M	1
	- Equipment Start-Up and Acceptance Check List	M	1
20 05 10	Basic Mechanical Materials and Methods	M	29
20 05 20	Mechanical Vibration Control	M	4
20 05 25	Mechanical Insulation	M	13
20 05 35	Demolition and Revision Work	M	2
20 05 50	Testing, Adjusting and Balancing	M	7
20 08 15	Mechanical Commissioning	M	24

DIVISION 21 - FIRE SUPPRESSION

Section	Title	Discipline	Pages
21 13 00	Fire Suppression Sprinkler Systems	M	7

DIVISION 22 - PLUMBING

Section	Title	Discipline	Pages
22 11 16	Domestic Water Piping and Valves	M	6
22 11 19	Domestic Water Piping Specialties	M	3
22 13 16	Drainage Waste and Vent Piping and Valves	M	2
22 13 19	Drainage Waste Piping Specialties	M	3
22 40 00	Plumbing Fixtures and Fittings	M	5
22 60 00	Gas and Vacuum Systems for Laboratory Facilities	M	6
22 67 00	Processed Water Systems	M	2

DIVISION 23 - HEATING, VENTILATING AND AIR CONDITIONING

Section	Title	Discipline	Pages
23 01 31	Air Duct Cleaning for HVAC Systems	M	3
23 05 94	Pressure Testing of Ducted Air Systems	M	3
23 08 01	Performance Verification Mechanical Piping Systems	M	3
23 08 02	Cleaning and Start-Up of Mechanical Piping Systems	M	4
23 21 13	Hydronic Piping and Valves	M	8
23 22 13	Steam and Condensate Piping	M	7
23 22 16	Steam and Condensate Piping Specialties	M	15
23 23 00	Refrigerant Piping, Valves and Accessories	M	5
23 25 00	HVAC Water Treatment	M	3
23 31 05	Ductwork - Standard	M	5
23 33 00	Duct Dampers & Accessories	M	12
23 33 19	Duct Silencers	M	3
23 34 00	HVAC Fans	M	4
23 34 15	Inline Fans	M	2
23 36 00	Air Terminal Units	M	3
23 37 13	Diffusers, Registers and Grilles	M	2
23 74 13	Air Handling Units - Packaged Outdoors	M	13
23 81 26	Split System Air Conditioners	M	5
23 82 16	Air Coils	M	2
23 82 29	Radiation Units	M	2
23 84 13	Humidifiers - Electric	M	4

DIVISION 25 - BUILDING AUTOMATION

Section	Title	Discipline	Pages
25 05 00	Integrated Automation	M	28
25 05 01	Flammable Vapor Sensor	M	4

DIVISION 26 - ELECTRICAL

Section	Title	Discipline	Pages
26 00 10	Electrical Work General Instructions	E	20
26 05 00	Basic Electrical Materials and Methods	E	30
26 05 05	Selective Demolition for Electrical	E	3
26 05 19	Low Voltage Cables	E	8
26 05 26	Grounding and Bonding	E	4
26 05 36	Cable Trays and Cable Ducts	E	8
26 05 70	Electrical Work Analysis and Testing	E	8
26 08 15	Electrical Work Commissioning	E	8
26 09 00	Lighting Controls	E	16
26 22 00	Distribution Transformers	E	4
26 24 16	Distribution Panelboards	E	7
26 24 17	Branch Circuit Panelboards	E	5
26 27 26	Wiring Devices	E	5
26 50 00	Lighting	E	7

DIVISION 27 - COMMUNICATIONS

Section	Title	Discipline	Pages
27 10 00	Structured Cabling	E	19
27 51 13	Overhead Paging Systems	E	4

DIVISION 28 - ELECTRONIC SAFETY AND SECURITY

Section	Title	Discipline	Pages
28 00 00	General Work Results for Electronic Safety and Security	E	10
28 10 00	Physical Access Control System	E	5
28 31 00	Fire Alarm System	E	11

DIVISION 31 - EARTHWORK

Section	Title	Discipline	Pages
31 00 00	Earthwork	A	7

VOLUME 1

Refer to Volume 1 for Divisions 0 - 14.

VOLUME 3

Refer to Volume 3 package for reports and reference documents.

END OF DOCUMENT

PART 1 - GENERAL

1.1 References

- .1 Drawings and general provisions of the Contract, including General and Supplementary Conditions and all Sections of Division 00 and 01 apply to and are part of this Section of the Specification.
- .2 The Specification is generally prepared in accordance with the format of the CSI/CSC Master Format 2004 edition.

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 takes precedence.
- .2 Perform All Work specified herein by experienced and licensed personnel.
- .3 Be responsible for advising product vendors of requirements of this Section.

1.3 Related Work

- .1 It is the intent of these specifications to furnish and install all materials and equipment as hereinafter specified and/or as shown on the drawings in such a manner as to leave each of the systems of the mechanical trades complete and in satisfactory condition.
- .2 Where used, words "Section" and "Division" shall also include other Sub-Contractors engaged on site to perform work to make building and site complete in all respects.
- .3 Where used, word "supply" shall mean furnishing to site in location required or directed complete with accessory parts.
- .4 Where used, word "install" shall mean secured in place and connected up for operation as noted or directed.
- .5 Where used, word "provide" shall mean supply and install as each is described above.
- .6 Where used, word "delete" or "remove" (and tenses of "delete" or "remove") shall mean 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 Consultant.
- .7 Where used, word "Authorities", shall mean any agencies, standards, rules and regulations that enforces the applicable laws, ordinances, rules, regulations or code of the place of the work.
- .8 "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.
- .9 Where used, word "work" shall mean all equipment, permits, materials and labour to provide a complete mechanical installation as required and detailed in the Drawings and Specifications.
- .10 Where used, words "Drawings" and "Specifications" are referred to; it means the "Contract Documents".

- .11 Where used, words "Prime Mechanical Contractor" shall mean the supervisory Mechanical Contractor of all Mechanical Sub-Contractors.
- .12 The term "exposed" means, within the line of sight of any person standing or sitting in the occupied space, unless defined otherwise in the following sections.
- .13 The term "concealed" means, not exposed, hidden from normal sight in furred spaces, shafts, ceiling spaces, walls and partitions.
- .14 The term "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.
- .15 The term "listed" means, that the materials or equipment are tested in accordance with applicable standards and are approved and listed for their intended use by a testing company approved by the Authorities having jurisdiction.
- .16 The term "approved", "approvals", etc., means, approved by Authorities having jurisdiction as conforming to the requirements of the Contract Documents.
- .17 The term "acceptable" or "acceptance", etc., means, acceptable to the Consultant as conforming to the requirements of the Contract Documents.
- .18 The term "submit for review" or "submit notice", etc., means, submit to the Consultant.
- .19 The term "subject to review" means, work or materials laid out for review by the Consultant. Obtain instruction from the Consultant before proceeding with the work. Submit further information, shop drawings, samples etc., as specified and/or as may be reasonably requested by the Consultant.
- .20 The term "accessible" used alone means, readily accessible by a person using tools as required without cutting or breaking out materials.
- .21 The term "noted" means, notes on the drawings, the detail drawings and on the Schedules.
- .22 "Mechanical Divisions" 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.
- .23 "Electrical Divisions" 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.
- .24 "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.
- .25 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.
- .26 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.
- .27 The terms "instructions" or "as instructed" or "where instructed" mean as instructed by the Consultant, including supplementary instruction notices; job site instruction notices; job site instructions by a field representative/ inspector appointed by the Consultant and including all comments made regarding submittal of shop drawings and samples for review.

1.4 Documents

- .1 Documents for bidding include but are not limited to issued Drawings, Specifications and Addenda.
- .2 Specification is arranged in accordance with CSI/CSC 50 Division Sections 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.
- .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 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.
- .12 In the case of discrepancies between the drawings and specifications, documents will govern in order specified in "General Conditions", however, when scale and date of drawings are same, or where discrepancy exists within specification, most costly arrangement will take precedence.

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 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 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);
 - .19 Institute of Electrical and Electronic Engineers (IEEE);
 - .20 International Standards Organization (ISO);
 - .21 Manufacturers Standardization Society of the Valve and Fittings Industry, Inc. (MSS);
 - .22 National Building Code of Canada (NBC);
 - .23 National Electrical Manufacturers Association (NEMA);

- .24 National Environmental Balancing Bureau (NEBB);
- .25 National Fire Protection Association (NFPA);
- .26 National Standards of Canada;
- .27 NSF International;
- .28 Occupational Health and Safety Act (OHSA);
- .29 Ontario Building Code (OBC);
- .30 Ontario Electrical Safety Code (OESC);
- .31 Sheet Metal and Air Conditioning Contractors' National Association (SMACNA);
- .32 Technical Standards and Safety Authority (TSSA);
- .33 Thermal Insulation Association of Canada (TIAC);
- .34 Underwriters' Laboratories of Canada (ULC);
- .35 Workplace Hazardous Materials Information System (WHMIS);
- .36 Material Safety Data Sheets by product manufacturers;
- .37 local utility inspection permits;
- .38 Codes, standards, and regulations of local governing authorities having jurisdiction;
- .39 additional codes and standards listed in Trade Sections;
- .40 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.
- .7 Work is to be performed by journeyperson tradesmen who perform only work that their certificates permit, or by apprentice tradesmen under direct on site supervision of experienced journeyperson tradesman. Journeyperson to apprentice ratio is not to exceed ratio determined by the Board as stated in Ontario College of Trades and Apprenticeship Act or local equivalent governing body in Place of the Work.
- .8 Journeyperson tradesmen are to have a copy of valid trade certificates available at site for review by Consultant at any time.
- .9 Experienced and qualified superintendent is to be on-site at times when work is being performed.
- .10 Coordinate work inspection reviews and approvals with governing inspection department to ensure that construction schedule is not delayed. Be responsible for prompt notification of deficiencies to Consultant and submission of reports and certificates to Consultant.
- .11 Properly protect equipment and materials on site from damage due to elements and work of trades, to satisfaction of Consultant. Equipment and materials are to be in new condition upon Substantial Performance of the Work.

- .12 Mechanical piping system work, including equipment, must comply in all respects with requirements of local technical standards authorities and CSA B51, Boiler, Pressure Vessels and Pressure Piping Code. Where required, mechanical work products must bear a CRN number.
- .13 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.

1.7 Healthcare Facility Standards

- .1 Comply with following CAN/CSA Standards:
 - .1 CAN/CSA Z317.13, Infection Control During Construction, Renovation, and Maintenance of Health Care Facilities: 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.
 - .2 CAN/CSA Z317.1, Special Requirements for Plumbing Installations in Health Care Facilities.
 - .3 CAN/CSA Z317.2, Special Requirements for Heating, Ventilation, and Air-Conditioning (HVAC) Systems in Health Care Facilities.
 - .4 CAN/CSA Z317.10, Handling of Waste Materials in Health Care Facilities and Veterinary Health Care Facilities.
 - .5 CAN/CSA Z8000, Canadian Health Care Facilities.
 - .6 CAN/CSA Z8001, Commissioning of Health Care Facilities.
 - .7 CAN/CSA Z7396.1 Medical Gas Pipeline Systems - Part 1 Pipelines for Medical Gases, Medical Vacuum, Medical Support Gases, and Anaesthetic Gas Scavenging Systems: Prepare a separate set of "as-built" white prints on a day-to-day basis for medical gas piping system work.
- .2 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.

1.8 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 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.

1.9 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 members in good standing with local Association of Professional Engineers 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:
 - .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.

1.10 Interpretation of Drawings

- .1 The drawings upon which this contract is based show the arrangements, general design and extent of the piping, ductwork and other systems. These systems are suitably outlined on the drawings with regard to sizes, locations, general arrangement and installation details. The mains and connections thereto are shown more or less in diagram, except where in certain cases, the drawings may include details giving the exact locations and arrangements required. All piping and ductwork shall be concealed unless shown otherwise. The Mechanical Contract Drawings do not intend to show Architectural or Structural details.
- .2 Where any parts of the system and/or pieces of equipment are located by dimensions on the drawings, said dimensions shall be checked and verified in the field. Each Division shall make without additional charge or expense to the Owner, any necessary changes, additions or offsets to the runs to accommodate structural conditions. The Consultant shall be notified immediately, and his authority secured in writing for such revisions before proceeding with the work.
- .3 As the work progresses, and before installing fixtures and other fittings and equipment which may interfere with the work of other trades, each Contractor shall consult with the Consultant and obtain detail drawings or instructions for the exact location of such equipment.

1.11 Existing Services

- .1 Where work involves breaking into or connecting existing services, carry out work at times directed by governing authorities, with minimum of disturbance to the premises and its operation.
- .2 Before commencing work, establish location and extent of service lines in area of work

and notify Consultant of finding.

- .3 Where unknown services are encountered, immediately advise Consultant and confirm findings in writing.
- .4 Remove abandoned service lines. Cap or otherwise seal lines at cut-off points, in manner approved by authorities having jurisdiction over service.
- .5 Record locations of maintained, re-routed and abandoned service lines. The sub-contractors concerned shall provide this Division with all necessary dimensions required to accurately locate those services.
- .6 Where the location of any of these utilities has been shown on the plans, such information is not guaranteed. It is the responsibility of this Division to verify locations, elevations, etc., immediately after they move on the site. If for any reason the information obtained necessitates changes in procedures or design, they must advise the Consultant at once. If this verification of existing conditions is not done at the outset and any problems arise, the responsibility for same is entirely this Division's.
- .7 Where it is necessary to temporarily shut down equipment or services serving essential areas, this Division shall include premium costs to ensure the work force is scheduled for "round the clock" operation in order to minimize disruption and equipment downtime.

1.12 Discrepancies & Omissions

- .1 The specifications are to be considered as an integral part of the plans which accompany them; neither the plans nor the specifications shall be used alone. Any item or subject omitted from one, but which is mentioned or reasonably implied in the other, shall be considered as properly and sufficiently specified, and must therefore, be provided. Notify the Consultant in writing of any discrepancy between the drawings and the Specifications, or omissions from Documents, or having doubt as to their meaning or intent. Misinterpretations of either the plans or the specifications shall not relieve this Division of responsibility.
- .2 Carefully examine Documents and visit the site of the building to determine and review existing site conditions that will or may affect work and become thoroughly familiar with all the conditions to be met in carrying out the work covered by these specifications. Include for such conditions in Bid Price. No extras will be allowed for failure to properly evaluate conditions which affect the scope of the work included in Divisions 21, 22, 23 and 25.
- .3 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.

1.13 Workplace Safety

- .1 Comply with requirements of Workplace Hazardous Materials Information System (WHMIS) regarding use, handling, storage and disposal of hazardous materials. Submit WHMIS MSDS (Material 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 Consultant.

1.14 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, 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;
 - .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 Shut-off valves, balancing devices, air vents, equipment and similar products, particularly such products located above suspended ceilings must be located for easy access for servicing and/or removal. Products which do not meet this location requirement are to be relocated to an 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.

1.15 Coordination of Work

- .2 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 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. Remove and replace any 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.

1.16 Electrical Wiring & Wiring Diagrams

- .1 All motors for equipment under this Division will be by this Division. All starters, switches and power wiring will be provided by Division 26, as noted. Where electrical requirements for equipment exceed the provisions described in electrical specifications, this Contractor shall provide labour and material as required to complete the installation. All motors, switches and equipment shall be of Canadian manufacturer and as per Section 20 05 10.
- .2 Provide with shop drawings, a comprehensive wiring diagram for all mechanical equipment requiring review. Shop drawings will not be reviewed unless accompanied by the wiring diagrams.
- .3 In addition to the wiring diagrams provided by the suppliers of the equipment, this Division shall engage an experienced Mechanical/Electrical Designer to draw wiring diagrams specifically for this project, showing each piece of electrically-wired mechanical equipment that is supplied or connected to by this Division. The drawings shall be bound in a three-ring binder entitled 'Wiring Diagrams' (three copies required). The

drawings shall include the following:

- .1 8-1/2" x 11" or 17" x 11" sheet size with drawing title, job title, drawing number, date, name of draftsman and designer
 - .2 Index for the above
 - .3 Schematic wiring diagram of each electrically connected item of equipment labelled with the specific designation used on the project drawings (i.e. P-1, AHU-1, RF-1, EF-1, H-1, CH-1, UH-1, FC-1 etc.).
 - .4 Showing motor HP, kW, voltage
 - .5 Terminal block designation and connection number
 - .6 Starter and relays for mechanical equipment supplied and installed by Division 26
 - .7 Power panel number and circuit number of feeder
 - .8 All thermostat, relays, damper motors and controllers, pressure switches and interconnection interlocks. Where the Temperature Controls Sub-Contractor shop drawings show the detailed wiring, these drawings may show the Temperature Controls drawing number references only.
- .4 If all of the information is not available from the shop drawings and project drawings, the information shall be determined from field visits.
 - .5 This section of the work shall be completed by Division 25.
 - .6 Refer to Division 26, 'Wiring for Mechanical Equipment' for wiring of mechanical equipment.

1.17 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.
- .2 No openings are permitted through completed structure without written approval of 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 directed by Owner and coordinated with Consultant, do not leave any openings unprotected and unfinished overnight.

1.18 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. Be responsible for confirming locations of equipment with Consultant prior to construction.

1.19 Products

- .1 Be responsible for ordering of products (equipment and materials) in a timely manner in order to meet project-scheduling timelines. Failure to order products to allow manufacturers sufficient production/delivery time to meet project-scheduling timelines is an unacceptable reason to request for 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 and are to comply with applicable respective Canadian standards. References to UL listings of products to include requirements that products are to be also Underwriters Laboratories of Canada (ULC) listed for use in Canada. Products are to meet or exceed latest ANSI/ASHRAE/IES 90.1 standards, as applicable. Do not supply any products containing asbestos materials or PCB materials.
- .3 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.
- .4 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.
- .5 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.
- .6 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.
- .7 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.

- .8 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 accepted in writing by Consultant.
- .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 Products supplied by a manufacturer/supplier other than a manufacturer listed as acceptable may be considered for acceptance by Consultant if requested in writing with full product documentation submitted, a minimum of 10 working days prior to Bid closing date.
- .12 Any proposed changes 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 Consultant, and costs for review, to be borne by Contractor.
- .13 Whenever use of product other than based specified products or named as acceptable is being supplied, time for process of submission of other products and Consultant's review of products will not alter contract time or delay work schedule.

1.20 Material Substitution

- .1 The following requirements are aimed to establish a certain quality of materials to be used.
- .2 Besides, the objective is not to eliminate the loyal competition in the tender process applied to materials and substitute products.
- .3 Equivalences can be submitted on a list separated from the tender form, but attached to the basic submission. A global amount for several equivalences is not acceptable. If no list is annexed to its basic submission, the Contractor accepts and agrees to do the

works such as written in the specification for the aforementioned project with the specified materials.

- .4 No request of replacement will be studied during the submission period and if it is received after the opening of the submissions, except when the material or the concerned product became unavailable. Only the equivalence proposition in appendix of the basic submission will be studied.
- .5 The equivalences will be accepted only on the following conditions:
 - .1 Equivalence must be submitted before the contract;
 - .2 Proofs of equivalences will be required and this at the Supplier's fees;
 - .3 Samples of the proposed material or equipment and the specified material or equipment may be required;
 - .4 The main points of comparison are: construction, efficiency, capacity, dimensions, weight, service access, minimal standard, availability and delivery of spare parts, maintenance, delivery deadlines, origin of the product, etc.
- .6 Any equivalence requiring an increase of the installation time or a surplus of auxiliary materials or any modification which would ensue from it, will not justify an additional payment for the Contractor. The basic price has to include all these changes.
- .7 Documents having been prepared with the dimensions and the characteristics of devices specified in the specification, the Contractor is solely responsible to make sure that the equivalence he proposes can settle down without change in the plans, not so as to modify the conditions of the original design and the spirit of the contract, and has to verify that all dimensions of the equivalences are suitable to the project. He has to inform the Engineer, in writing, that the equipment which he suggests as equivalence meets these requirements and to ask for its approval.
- .8 The Consultant reserves the right to accept or to refuse one or several equivalences (materials considered equivalent by the Contractor); his decision is final. The basic price of the submission will be adjusted more or less, according to the acceptance of the Engineer.

1.21 Access Panels & Doors

- .1 **For Non-Fire-Rated Separation (Drywall Ceilings & Walls):**
 - .1 Supply for finished drywall ceilings and walls, APS (Bauco-Plus II) recessed access door of a suitable size to provide access to plumbing cleanouts and for servicing dampers, valves and equipment which will be concealed.
 - .2 Access door to be designed for flush installation in drywall surfaces. Access door is recessed 1" to receive drywall. The flange of the door is a textured galvanized steel tapping bend with pre-punched holes. Drywall compound is applied over the beading at the same time as the drywall joints are finished
 - .3 Door to be 16 gauge prime-coated steel with 14 gauge steel frame and screwdriver operated can latch.
 - .4 Prime Mechanical Contractor shall include for the installation of all access doors supplied by Division 21, 22, 23 and 25. Engage and pay the respective General Trade on site to install same.
- .2 **For Non-Fire-Rated Separation (Not Drywall Ceilings & Walls):**
 - .1 Supply for finished ceiling or wall surfaces that are not of drywall construction, Smillie, McAdams Summerlin Limited, Le Hage (Ancon Industries Incorporated) access doors of a suitable size to provide access to plumbing cleanouts and for servicing dampers, valves and equipment which will be concealed. Minimum

- size for reach-in access to be 12" x 12" (300 mm x 300 mm) and 18" x 18" (450 mm x 450 mm) for man access.
- .2 Door and frame to be 16 gauge prime-coated steel with concealed hinges and positive locking and self-opening screwdriver lock.
- .3 Prime Mechanical Contractor shall include for the installation of all access doors supplied by Divisions 21, 22, 23, 25. Engage and pay the respective General Trade on site to install same.
- .3 **Fire-Rated Separations:**
 - .1 Supply access doors in fire-rated ceiling assemblies, walls and shafts. Access doors shall be Smillie, McAdams Summerlin Limited, Le Hage (Ancon Industries Incorporated), ULC listed, manufactured and installed in accordance with NFPA-80.
 - .2 Door to be complete with 16 gauge steel frame with concealed continuous hinge and key-operated lock and self closer, double wall 20 gauge prime-coated steel door with 2" (50 mm) thick insulation.
 - .3 ULC rating 1-1/2 hours, temperature rise maximum 250°F (120°C) in thirty (30) minutes.
 - .4 Prime Mechanical Contractor shall include for the installation of all access doors supplied by Divisions 21, 22, 23, 25. Engage and pay the respective General Trade on site to install same.
- .4 For access doors located in the Operating Room ceiling and in the soffit beneath the Operating Room addition, refer to architectural for final locations and details.
- .5 Size access panel doors to provide adequate access and correspond with the type of structural and architectural finish.
- .6 Ensure proper fire resistance rating of doors/panels in fire separations.
- .7 Provide the following:
 - .1 Type RW recessed for "SG" board in wet areas.
 - .2 Type TM flush mount for tile and masonry.
 - .3 Type WB flush for wall board.
- .8 **Materials & Finish:**
 - .1 Galvanized bonderized steel, phosphate-dipped with baked-on rust inhibitive grey prime finish.
 - .2 Stainless steel with No. 4 finish in Shower, Wet Washrooms and Drying Areas.
- .9 **Acceptable Products:**
 - .1 Le Hage
 - .2 Milcor
 - .3 Acudor
 - .4 Nystrom
 - .5 Access Panel Solutions Inc. (Bauco - Plus II) for Drywall

1.22 Concrete Work & Supports

- .1 Installation of concrete bases for all mechanical equipment shall be by this Division.
- .2 Prime Mechanical Contractor shall construct the bases. Provide accurate templates for

the concrete trade to pour the bases.

- .3 For equipment suspended from the building structure, provide all structural members, platforms, brace and hanger rods as required. Method of attachment to be reviewed with the Structural Consultant before proceeding with the installation.
- .4 For pre-cast slabs, Prime Mechanical Contractor shall co-ordinate all openings for pipes and ducts with the Precast Concrete Erector. The Precast Concrete Erector shall be responsible for drilling or cutting all holes through precast slabs. Holes through the structural slabs shall be sleeved as specified herein.

1.23 Flashing

- .1 The Prime Mechanical Contractor shall provide flashings for the work of this Division. If not specified, a description is to be supplied for approval.
- .2 Generally, all pipes and small ducts or stacks passing through the roof shall be flashed with an 18 gauge steel sleeve soldered watertight and fastened to the roof deck before the roofing is applied with a minimum of 8" (200 mm) overlap along the roof deck and extending 8" (200 mm) up the pipe or duct, sealed with a weather skirt.
- .3 Vent stacks may be flashed with patented flashing cones provided with the equipment.
- .4 Where large ducts pass through roof, curbs and flashing shall be by this Division where shown on the roofing plan. If not shown, all curbs, flashings and counter flashing are by this Division.

1.24 Painting

- .1 Mechanical equipment, grilles, fans, shall be shop prime coated unless noted to be finish coated. Where the prime coat or finish coat has been marred, touch up the surface.
- .2 Equipment exposed to the exterior weather conditions are to be shop finished with rust-resistant paint or as specified in equipment specification.
- .3 Leave all work in a clean, paintable condition.
- .4 All exposed structural members required for supporting piping, ductwork and equipment shall be galvanized. Where threaded rods are used, they shall be cadmium plated including washers and nuts.
- .5 Paint pipe sleeves one (1) coat primer.
- .6 Paint all relief and drain pipes serving Mechanical equipment, flat black.

1.25 Cutting & Patching

- .1 It is the responsibility of the Prime Mechanical Contractor to install sleeves for piping and ducts, and provide frames for opening for grilles, louvres, fans and similar equipment to be built into the existing building. All structural components must have the location, size and proposed method of cutting approved before proceeding.
- .2 Should damage occur to the work of other trades and Divisions, remedial work will be done by the trade who originally installed the work, at the expense of the sub-contractor who caused the damage.
- .3 Where pipes and ducts pass through walls in the existing building, the cutting and patching is by the Prime Mechanical Contractor.
- .4 Co-ordinate work with Division 01 for Firestopping and Smoke Seals.

1.26 Sleeves

- .1 Provide pipe sleeves at points where pipes (plumbing, heating, sprinkler, gas, etc.) pass

through masonry of minimum 22 gauge thickness galvanized sheet steel with lock seam joints. Where ducts pass through masonry provide suitable 18 gauge galvanized steel sleeves. Size sleeves on insulated piping or ducts to permit insulation to continue through. Where piping or ducts pass through concrete or frame construction, provide 1/8" (3 mm) thick galvanized iron sleeves. On copper pipe provide copper pipe sleeves.

- .2 Use cast iron or steel pipe sleeves with annular fin continuously welded at midpoint, through foundation walls and where sleeve extends above finished floor.
- .3 Provide 1/8" (3 mm) clearance all around, between sleeve and pipes or between sleeve and insulation and where piping passes below footings, provide minimum clearance of 2" (50 mm) between sleeve and pipe. Backfill up to underside of footing with concrete of same strength as footing.
- .4 Terminate sleeves flush with surface of concrete and masonry and 2" (50 mm) above floors. Not applicable to concrete floors on grade.
- .5 For pipes passing through roofs, use cast iron sleeves with caulking recess and flashing clamp device. Anchor sleeves in roof construction; caulk between sleeve recess and pipe; fasten roof flashing to clamp device; make watertight durable joint.
- .6 Fill voids around pipes.
 - .1 Where sleeves pass through walls or floors, caulk space between insulation and sleeve or between pipe and sleeve with waterproof, fire-retardant, non-hardening mastic. Seal space at each end of sleeve with waterproof, fire-retardant, non-hardening mastic.
 - .2 Ensure no contact between copper pipe and ferrous sleeve.
- .7 Co-ordinate work with Division 01 for Firestopping and Smoke Seals.

1.27 Escutcheons & Plates

- .1 Provide on exposed pipes passing through finished walls, partitions, floor and ceilings.
- .2 Use chrome or nickel-plated brass, solid type with set screws for ceiling or wall mounting.
- .3 Inside diameter shall fit around finished pipe. Outside diameter shall cover sleeve.
- .4 Where sleeve extends above finished floor, escutcheons or plates shall clear sleeve extension.
- .5 Secure to pipe or finished surface.

1.28 Dielectric Couplings

- .1 Provide wherever pipes of dissimilar metals are joined.
- .2 Provide insulating unions for pipe sizes 2"Ø (50 mm) and smaller, and flanges for pipe sizes 2-1/2" (65 mm) and larger. Brass adaptors and bronze valves will not be accepted.
- .3 Provide an isolating separation wherever piping may touch dissimilar metal studs, joists, concrete, etc.

1.29 Fire Stopping

- .1 The Prime Mechanical Contractor is responsible for all fire stopping related to the work of Division 21, 22, 23 and 25 including, but not limited to, the ductwork, piping and control wiring.

1.30 Impeller, Sheave & Belt Changes

- .1 The Prime Mechanical Contractor to carry the costs for pump impeller, fan sheave and

belt changes. See Section 20 05 50 - Testing, Adjusting and Balancing.

1.31 Non-Ferrous Materials

- .1 Materials within designated imaging rooms to be of non-ferrous construction as coordinated 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.

1.32 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 review by and coordination with Consultant. Include for the cost of dismantling and reassembling equipment, where required, to the manufacturer's approval.
- .2 Direct this work by qualified people normally engaged in rigging, hoisting and handling of equipment.
- .3 Immediately remove from site scaffolding, rigging and hoisting equipment when no longer required.
- .4 Do not place major scaffolding/hoisting equipment loads on any portion of structure without approval from Consultant.

1.33 Protection

- .1 Protect work from damage. Securely plug or cap open ends of conduits, pipes, ducts or equipment to prevent entry of dirt, dust, debris, water, snow or ice. Cover all items cast into concrete floors/walls such as floor drains, cleanouts, etc., prior to pour, with heavy plastic tape or duct tape. Clean all piping, ducting, conduits and equipment inside and outside before testing.
- .2 Material stored on site shall be protected from weather and kept dry and clean at all times. Take care to avoid corrosion of metal parts. Protect all bearings and motors from damage due to moisture and dust. Equipment not yet in operation shall be turned over at least at monthly intervals to prevent bearing deterioration.

1.34 Rights Reserved

- .1 Rights are reserved to furnish any additional detail drawings which, in the judgement of the Consultant, may be necessary to clarify the Work and such drawings shall form a part of the Contract.

1.35 Superintendence

- .1 Maintain at this job site, at all times, qualified personnel and supporting staff with proven experience in erecting, supervising, testing and adjusting projects of comparable nature and complexity.

1.36 Co-Ordination

- .1 The Prime Mechanical Contractor is responsible for co-ordinating the mechanical work herein to suit Project Phasing Schedule.
- .2 Co-ordinate all Mechanical Work with the work of any other Divisions to avoid conflicts. Be responsible for modifying the work of this Division to accommodate space conflicts.
- .3 Failure to co-ordinate will result in installed work being removed and new work put in

place without cost to the Owner.

1.37 Maintenance

- .1 Furnish spare parts in accordance with Division 01 requirement and as follows:
 - .1 One set of packing for each pump.
 - .2 One casing joint gasket for each size pump.
 - .3 One filter cartridge or set of filter media for each filter or filter bank in addition to final operation set.
 - .4 One glass for each gauge glass.
- .2 Provide one set of special tools required to service equipment as recommended by manufacturers and in accordance with Division 01 requirement.
- .3 Furnish one commercial quality grease gun, grease and adapters to suit different types of grease and grease fittings.

1.38 Delivery, Storage & Handling

- .1 Transport, store and handle the materials in conformance with the manufacturer's instructions.
- .2 Delivery and receipt:
 - .1 Deliver the materials to the job site in their original packaging. The name and the address of the manufacturer marked must be labelled on the packaging.
- .3 Storage and protection:
 - .1 Store the materials in a dry environment.
 - .2 Store the materials in the temperature and humidity conditions recommended by the manufacturer, and protect them from exposure to extreme weather conditions.
- .4 Packaging waste management: recover the packaging waste so that it may be re-used or recycled or reclaimed by the manufacturer. This includes pallets, lockers, packing and other packing material.

1.39 Tendering Instructions

- .1 Refer to the General Conditions for the Instructions to Bidders.
- .2 The Prime Mechanical Contractor agrees to employ those subcontractors proposed in the Mechanical Form(s) of Tender and accepted by the Owner at the signing of the Contract.
- .3 The Owner may, for reasonable cause, object to the use of a proposed subcontractor and consequently, may require the Prime Mechanical Contractor to employ one of the other subcontractor bidders.
- .4 In the event that the Owner requires a change from a proposed subcontractor, originally proposed by the Prime Mechanical Contractor, the Contract Price shall be adjusted by the difference in cost.
- .5 The Prime Mechanical Contractor shall not be required to employ as a subcontractor, a firm to whom he may reasonably object.
- .6 Work of subcontractors named at the time of Tender or substitutions authorized by the Owner will be recognized as being in accordance with the Contract Documents and any payments will be approved by the Owner, only to such subcontractors.

1.40 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 approval, a quotation being 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 Unless otherwise specified in Divisions 00 or 01, following additional requirements apply to all quotations submitted:
 - .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;
 - .3 mechanical material labour unit costs are to be in accordance with Mechanical Contractors Association of America Labor Estimating Manual, less 25%;
 - .4 electrical material 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 journey person 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.
- .4 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.
- .5 Make requests for changes or revisions to work to Consultant in writing and, if Consultant agrees, will issue Notice of Change.
- .6 Do not execute any change or revision until written authorization for the change or revision has been obtained from Consultant.

1.41 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 Consultant's approval and 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.

1.42 Notice for Required Field Reviews

- .3 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 5 working days' notice in writing to Consultant.
- .4 If Consultant is unable to attend a field review when requested, arrange an alternative date and time.
- .5 Do not conceal work until Consultant advises that it may be concealed.
- .6 When Consultant is requested to perform a field review and work is not ready to be reviewed, reimburse Consultant for time and travel expenses.

1.43 Submittals

- .1 Submittals: in accordance with Division 01.
- .2 Shop drawings to show:
 - .1 Mounting arrangements.
 - .2 Operating and maintenance clearances.
- .3 Shop drawings and product data accompanied by:
 - .1 Detailed drawings of bases, supports, and anchor bolts.
 - .2 Acoustical sound power data, where applicable.
 - .3 Points of operation on performance curves.
 - .4 Manufacturer to certify current model production.
 - .5 Certification of compliance to applicable codes.
- .4 In addition to transmittal letter referred to in Division 01: use MCAC "Shop Drawing Submittal Title Sheet". Identify section and paragraph number.
- .5 Closeout Submittals:
 - .1 Provide operation and maintenance data for incorporation into manual specified in Division 01.
 - .2 Operation and maintenance manual approved by, and final copies deposited with, Consultant before final inspection.
 - .3 Operation data to include:
 - .1 Control schematics for systems including environmental controls.
 - .2 Description of systems and their controls.
 - .3 Description of operation of systems at various loads together with reset schedules and seasonal variances.
 - .4 Operation instruction for systems and component.
 - .5 Description of actions to be taken in event of equipment failure.
 - .6 Valves schedule and flow diagram.

- .7 Colour coding chart.
- .4 Maintenance data to include:
 - .1 Servicing, maintenance, operation and trouble-shooting instructions for each item of equipment.
 - .2 Data to include schedules of tasks, frequency, tools required and task time.
- .5 Performance data to include:
 - .1 Equipment manufacturer's performance datasheets with point of operation as left after commissioning is complete.
 - .2 Equipment performance verification test results.
 - .3 Special performance data as specified.
 - .4 Testing, adjusting and balancing reports as specified in Section 20 05 50 - Testing, Adjusting and Balancing.
- .6 Approvals:
 - .1 Submit two (2) copies of draft Operation and Maintenance Manual to Consultant for review. Submission of individual data will not be accepted unless directed by Consultant.
 - .2 Make changes as required and re-submit as directed by Consultant.
- .7 Additional data:
 - .1 Prepare and insert into operation and maintenance manual additional data when need for it becomes apparent during specified demonstrations and instructions.
- .8 As-built drawings:
 - .1 Prior to start of Testing, Adjusting and Balancing for HVAC, finalize production of as-built drawings.
 - .2 Identify each drawing in lower right-hand corner in letters at least 12 mm high as follows: - "AS BUILT DRAWINGS: THIS DRAWING HAS BEEN REVISED TO SHOW MECHANICAL SYSTEMS AS INSTALLED" (Signature of Contractor) (Date).
 - .3 Submit to Consultant for review and make corrections as directed.
 - .4 Perform testing, adjusting and balancing for HVAC using as-built drawings.
 - .5 Submit completed reproducible as-built drawings with Operating and Maintenance Manuals.
- .9 Submit copies of as-built drawings for inclusion in final TAB report.
- .10 Site records:
 - .1 Engineer will provide one set of mechanical drawings. Mark changes as work progresses and as changes occur.
 - .2 Transfer information to reproducible, revising reproducible to show work as actually installed.
 - .3 Use different colour waterproof ink for each service.
 - .4 Make available for reference purposes and inspection.

1.44 Record Drawings

- .1 The Consultant will provide an extra set of whiteprints to be marked up by this Division

as the job progresses, showing all changes and deviations from the plans, so that on completion of the job, the Consultant will have a record of the exact location of all piping, ductwork and equipment. These drawings shall be available during construction at all times and will be reviewed monthly by the Consultant.

- .2 Record drawings shall locate all concealed shut-off valves, dampers, control valves and concealed air vents.
- .3 The Consultant will provide to the Prime Mechanical Contractor the AutoCAD disk for a fee. The Prime Mechanical Contractor will be required to sign "Transfer of Files on Electronic Media" Form and pay the fee in order to receive the files. A sample of this form is attached to the section. Return completed disks to the Consultant with Maintenance Manuals.

1.45 Interference Drawings

- .1 Before shop fabrication begins or undertaking installation work inside the building, prepare an integrated set of mechanical interference sketches, where indicated on the drawings.
- .2 These sketches shall be prepared by the Prime Mechanical Contractor with the co-operation of other trades and shall show the location or space allocated for the work of each trade.
- .3 Submit two (2) copies of detailed interference sketches, showing structural members, electrical conduits, devices and all Mechanical elements to the Consultant for review and general approval before proceeding with the work.
- .4 Copies of these reviewed interference drawings shall be submitted to all trades, the General Contractor, the Architect, and the Consultant, and general approval shall be obtained before the space allotment and installation.
- .5 As a minimum, interference drawings shall be made for all areas of mechanical equipment rooms, duct shafts and corridor ceiling spaces.
- .6 Work that has been installed before review of interference drawings, and has been determined that it is in conflict with the building, shall be removed from the site at no extra cost to the Owner. The work, approved by the Consultant, shall be installed at no extra cost to the Owner.

1.46 Materials & Equipment - Acceptable Products, Base Bid, Alternate Products, Unsolicited Alternates

- .1 Provide materials and equipment in accordance with Division 01.
- .2 Equipment and material to be CSA certified and manufactured to standards specified herein.
- .3 Factory assemble control panels and component assemblies.
- .4 The Specification indicates Acceptable Product manufacturers (or Acceptable Manufacturers) for various products, materials and systems which make up the mechanical work. The Tender Price shall be based on any of the "Acceptable Products".
- .5 The Specifications may also indicate Base Bid and Approved Alternate (or Alternate Products) manufacturers for various products, materials and systems. For such cases, the Tender Price MUST be based on the "Base Bid" manufacturer/system. The net dollar addition or deduction to/from the Tender Price for each "Approved Alternate" shall be indicated on the Bid Form 00 41 00 or letter attached to the Bid Form for consideration by the Consultant.
- .6 The net dollar deduction from the Tender Price if the alternate is accepted. This value shall reflect all costs associated with the incorporation of the alternate into the work,

including any required changes in Architectural, Structural, Electrical and other Mechanical Sections and the Consultants costs of revising the design to suit.

- .7 The Owner reserves the right to accept or reject any or all "Approved Alternates".

1.47 Manufacturers, Shop Drawings & Submittals

- .1 Before fabrication of any materials and/or equipment, submit shop drawings and data sheets covering all items of equipment listed as requiring shop drawings. Shop drawings to be submitted are listed in each section under SUBMITTALS. These will be reviewed and returned to the Contractor. Materials shall not be ordered until "accepted" review has been given.
- .2 The Prime Mechanical Contractor is to consult with the Consultant on the manner in which drawings will be handled. Supply metric information for metric projects.
- .3 Equipment requiring electrical wiring by Division 26 will have the electrical wiring diagrams submitted with the shop drawings. Shop drawings will not be reviewed unless wiring diagrams accompany the equipment drawings.
- .4 For whiteprint-type shop drawings, eight (8) copies as required. For 8-1/2" x 11" fixture cuts, submit eight (8) copies of booklets as required.
- .5 The Prime Mechanical Contractor is to keep track of the shop drawings and the subsequent equipment delivery using a Review Summary Form similar to the form shown below. This form is to be updated and presented at each job meeting until all the equipment is on the job.
- .6 The shop drawings must apply to the equipment under consideration. Advertising literature and comprehensive data sheets are not acceptable.
- .7 The shop drawings must contain the following information: job name, equipment tag, actual dimensions of unit and dimensioned location and size of all field connections, model, performance curves, capacity, HP, voltage and all accessories listed in the specifications and/or being provided, and the operating points of the proposed equipment. Room schedules are to be provided for multiple units.
- .8 The shop drawings submitted for review must first be carefully checked by the Prime Mechanical Contractor and bear the Contractor's identification review stamp or signature. Drawings will not be considered otherwise.
- .9 Shop drawing review is for general conformance with the design concept of the project and general compliance with the information given in the contract documents. Any action shown is subject to the requirements of the contract documents. Contractor is responsible for the dimensions which shall be confirmed and correlated at the job site; fabrication processes and techniques of construction; coordination of his or her work with that of all other trades; and the satisfactory performance of his or her work.
- .10 Shop drawings will be returned "No Exception Taken", "Revise & Resubmit", "Make Corrections Noted, Resubmission Not Required" or "Rejected, Submit Compliant Product/System".
 - .1 "No Exception Taken" Drawings shall be considered as conforming with the design concept.
 - .2 "Make Corrections Noted, Resubmission Not Required" Drawings shall be considered as conforming with the design concept once corrections have been made as noted on the drawings. This notation shall not hold up manufacture. These drawings shall be corrected for final submission with project Maintenance/Operation manuals.
 - .3 "Revise & Resubmit" Drawings shall be considered as conforming with the design concept once corrections have been made as noted on the drawings.

These drawings shall be corrected and resubmitted for final review but such resubmission shall not hold up manufacture.

- .4 "Rejected, Submit Compliant Product/System" These drawings are rejected and work shall not proceed on the manufacture of this equipment. The drawings shall be re-drawn or corrected, and resubmitted with corrections as noted on the drawings or a letter attached thereto.
- .11 All shop drawings must be submitted promptly.

'B' - Revise & Resubmit

'D' - Rejected, Submit Compliant Product/System

1.48 Operation & Maintenance Manuals

- .1 During the one (1) year guarantee period, commencing after Substantial Completion Letter has been issued by the Consultant's Office, maintain all equipment installed as part of this Division. This is to include lubrication of bearings, cleaning of strainers, etc., except the replacement of air filters and water treatment. This agreement shall be part of the written guarantee. This work shall be carried out in the presence of the owner's representative, and a letter shall be sent to the Consultant stating that this work was carried out. Three (3) maintenance inspections must be carried out by the Prime Mechanical Contractor during this one (1) year period, evenly spaced over the time frame. (after Substantial Completion Letter issued by the Architect). Submit written report to Owner and Consultant after each inspection.
- .2 This maintenance shall continue up to the date of instruction of the Owner's designated representatives, at which time each piece of equipment is to be lubricated and checked in the presence of the Owner's representative(s).
- .3 Not later than three (3) weeks prior to application for inspection by Consultant for Substantial Performance, submit records and maintenance manuals to Consultant.
- .4 Prepare two (2) sets of "letters" sized, hard-cover, three-ring, black, maintenance manuals, containing dimensioned certified prints of each piece of mechanical equipment and Manufacturer's recommended maintenance instructions, air balancing reports, and wiring diagrams. Tabulated at the front of this binder is to be a maintenance schedule for each piece of equipment, and lubricant to be used, and a tabulation of things to be checked at each piece of equipment.
- .5 Maintenance Manuals will be requested by the Consultant shortly after the final submission of all shop drawings. Maintenance manuals must be submitted and reviewed before training of the Owner's personnel and before a final inspection will be carried out.
- .6 In addition to the three (3) maintenance inspections called for in Item .1, the Prime Mechanical Contractor shall organize and attend bi-weekly site meetings with the Owner's Representative to review mechanical system deficiencies. The meetings will commence after substantial completion of the project has been granted and extend for four (4) months for a total of nine (9) meetings. The Prime Mechanical Contractor will take minutes of each meeting indicating status of all mechanical deficiencies. The Prime Mechanical Contractor shall issue copies of the minutes to the Owner and Mechanical Consultant after each meeting.

1.49 Temporary or Trial Usage

- .1 Do not use any permanent Mechanical Systems during construction unless specific written approval is obtained from the Consultant.
- .2 Temporary or trial usage of any mechanical device, machinery, apparatus, equipment or materials shall not be construed as evidence of acceptance of same and no claim for damage shall be made for injury to or breaking of any part of such work which may so be used.
- .3 Where the Owner permits the use of a system the Prime Mechanical Contractor shall be in charge of and maintain all equipment in accordance with manufacturers instruction at all times the systems are in operation.
- .4 The use of permanent systems shall not invalidate the guarantee or warranty.
- .5 Prior to final acceptance, return all equipment to as new condition and provide supplier certification of same.

1.50 Time for Completion

- .1 Review the general contract requirement for completion dates. Identify at the time of tender any items which may affect the time for completion.
 - .1 Advise the Consultant if materials and equipment involves longer delivery times than indicated in the schedule.
 - .2 Monitor and expedite delivery of equipment and materials. If necessary, inspect at source of manufacture.
- .2 Be responsible for failure of, or delay in, the delivery of specified equipment.

1.51 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.

1.52 Testing & Adjusting

- .1 Test all piping systems for leaks providing gauges, materials and labour as required. Equipment furnished as part of the permanent installation shall not be used for testing purposes. Before testing, remove all equipment which is not designed to withstand the test pressures. All piping is to be tested before covering is applied, and before backfilling or concealing.
- .2 **Hydrostatic Tests:** All pressure pipe is to be tested as described in each Section. Test pressure shall be maintained for the times noted, during which time the pressure test shall remain constant without pumping.
- .3 **Gravity Piping:** All gravity drainage piping shall be given a ball test and a water test, which must be supervised and inspected by the local Plumbing Inspector.
- .4 All testing shall be done to the satisfaction and approval of the Consultant and the Division shall notify the Consultant forty-eight (48) hours prior to testing.
- .5 Before final payment, test the operation of each system and all equipment installed, make all necessary adjustments and replacements, and demonstrate to the satisfaction of the Consultant that all equipment is operating as intended and without undue noise and vibration.
- .6 All tests must be witnessed by the Owner's Authorized Representative. Failure to do so will result in a re-test.
- .7 If system pumps are used during the system flushing, Prime Mechanical Contractor shall supply and install replacement pump seals in each pump, once flushing is complete and tests results accepted.

1.53 Start-Up & Instruction

- .1 The Prime Mechanical Contractor shall start-up equipment and operate for a minimum of five (5) days. During this time, adjust controls, clean strainers, replace faulty gauges

and thermometers, fasten loose equipment and reduce noise.

- .2 The start-up procedure shall include the completion of the enclosed Equipment Start-Up and Acceptance Check List, which shall be signed by the Mechanical foreman, the Sheet Metal foreman, and Controls foreman where applicable and Electrical foreman certifying they have verified the equipment is ready for acceptance by the Consultant and Owner. When all of the Check Lists have been signed off, the Mechanical foreman and his Sub-Contractors shall demonstrate the operation of the equipment to the Consultant and Owner for sign off acceptance. There shall be an individual Check List sheet for each individual piece of equipment.
- .3 When the sign off procedure is complete, the Prime Mechanical Contractor shall instruct the Owner's designated representative in the operation and maintenance of all equipment. The Consultant and the Board's Commissioning agent shall be present during the operation instruction.

1.54 Operate & Adjust Systems

- .1 Operate all systems to full capacity and verify proper, safe, efficient operation of all parts and each complete system. Oil motors and grease bearings before operating equipment.
- .2 When work is complete and systems are in operation, adjust valves, belt drives, controls and thermostats so that there is an even distribution of cooling and heating throughout. Turn over to Owner necessary keys, handles and operating devices for each system.
- .3 Test for both heating and cooling days. Refer to Section 23 08 01 - Performance Verification Mechanical Piping Systems

1.55 Commissioning

- .1 An independent Commissioning Agent is retained by Owner to perform equipment and system commissioning work as specified in Division 01, and in Section entitled Mechanical Work Commissioning. Interface, cooperate and coordinate with Owner's Commissioning Agent. Submit copies of submittals such as shop drawings/product data sheets, schedules, O&M manuals, and test reports to Commissioning Agent as required.

1.56 Completion

- .1 Keep the premises in a clean and orderly condition during construction. All waste and unusable materials shall be promptly removed from the site.
- .2 Upon completion of this work, go over the entire installation, clean and polish all fixtures and equipment, and remove all surplus materials and rubbish of every description incidental to this work, leaving the installation neat and orderly.
- .3 Before final payment is made, the following items must be completed:
 - .1 Present to the Consultant "Maintenance Manuals" complete with air and water balancing reports, wiring diagrams and certified equipment prints.
 - .2 Present to the Consultant an as-built record set of drawings and CAD disk.
 - .3 Instruction of Owner's personnel in the maintenance and operation of all new equipment.
 - .4 Present to the Consultant completed Equipment Start-up and Acceptance Checklist.
 - .5 Present to the Consultant Test Certificates and results.
 - .6 Present to the Consultant Valve Tag Charts.
 - .7 Spare filters and frames, labelled and located where directed by the Owner.

- .8 Present to the Consultant start-up report for fan coil units.
- .9 Present to the Consultant start-up report for air handling unit.
- .10 Present to the Consultant Medical Gas Certification
- .11 Present to the Consultant complete controls commissioning report.
- .12 Present to the Consultant as-built drawings on CAD diskette.
- .13 Maintain a set of approved drawings on site available for review by authorities.
- .14 Perform the above work in a timely manner so as not to interfere with the progress of the project.
- .4 A value of 1% of the total contract price shall be withheld until points .3.1 to .3.14 are completed to the satisfaction of the Consultant.

1.57 Liability

- .1 Each Section and Trade shall:
 - .1 Assume full responsibility for laying out his work and for any damage caused to other Sections or Owner by improper location or carrying out of same.
 - .2 Be responsible for prompt installation of work in advance of concrete pouring, ceiling installation or similar work.
 - .3 Protect finished and unfinished work of this Division and work of other Sections from damage due to work of this Division.
 - .4 Be responsible for condition of material and equipment supplied. Be responsible for protection and maintenance of work completed until termination and acceptance.

1.58 Allowances

- .1 Include in Bid amount a prime cost allowance in amount of _____.
- .2 Allowance is for _____.
- .3 Amount of allowance is to be net and is to include product and material costs (less applicable trade discounts), including delivery to site and applicable taxes.
- .4 Other costs, including unloading and handling at site, installation, overhead and profit and other burdens are to be included in Bid amount, not in allowance.
- .5 Whenever costs are more or less than amount of allowance, Contract amount will be adjusted accordingly by Change Order.
- .6 Materials and products under allowance will be selected by Owner in sufficient time to avoid delays to work, and Owner reserves right to take entire or any part of allowance out of Contract amount at any time.
- .7 Expenditure from above allowances may be made only upon receipt of order signed by Consultant. Relationship of Contractor and Subcontractors performing work to be paid out of allowances to be strictly between Contractor and Contractor's Subcontractors.

PART 2 - PRODUCTS

2.1 Materials

- .1 Not used

PART 3 - EXECUTION

3.1 Painting Repairs & Restoration

- .1 Prime and touch up marred finished paintwork to match original.
- .2 Restore to new condition, finishes which have been damaged.

3.2 Cleaning

- .1 Clean interior and exterior of all systems including strainers. Vacuum interior of ductwork and air handling units.

3.3 Demonstration

- .1 Consultant will use equipment and systems for test purposes prior to acceptance. Supply labour, material, and instruments required for testing.
- .2 Supply tools, equipment and personnel to demonstrate and instruct operating and maintenance personnel in operating, controlling, adjusting, trouble-shooting and servicing of all systems and equipment during regular work hours, prior to acceptance.
- .3 Use operation and maintenance manual, as-built drawings, and audio visual aids as part of instruction materials.
- .4 Instruction duration time requirements as specified in appropriate sections.

3.4 Protection

- .1 Protect equipment and systems openings from dirt, dust, and other foreign materials with materials appropriate to system.



220 Commerce Valley Drive West, Suite 110
Markham, ON L3T 0A8 CANADA
T: 905.695.3217 • www.exp.com

Transfer of Files on Electronic Media

Consultant of Record ("Consultant"): EXP Services Inc.

Contractor ("Contractor"): _____

Re: Project Name, Project Address, ("Owner"): _____

The Contractor hereby acknowledges requesting from the Consultant, electronic data containing graphic (electronic) representation of Engineering Drawings as per attached list of drawings, subject to the condition that the said drawings are to be used only for information and reference in connections with the Owner's use and occupancy of the Project. The Contractor shall be responsible for checking and verifying all dimensions and details, or quantities of materials and for the co-ordination of architectural, structural, mechanical and electrical elements as required to facilitate complete and accurate fabrication and installation. Any omissions and discrepancies shall be reported to the Consultant. The Contractor hereby warrants to the Consultant that the drawings will only be used for development of shop drawings/record drawings. The drawings shall not be used for any other project **or purpose** either by the Contractor or others. The Contractor further warrants not to alter the electronic data or the information contained therein, in any way except for the above noted purposes, and acknowledges that such unauthorized use or alteration of the original work is protected in accordance with the Copyright Act and subject to penalties prescribed therein.

The Contractor hereby acknowledges that the said electronic data contain information which may be updated or altered at any time by the Consultant, and that it is the responsibility of the Contractor to make themselves aware of these changes, in a timely manner. In the event of a conflict between the drawings issued to the Contractor and the sealed Contract Drawings, the sealed Contract Drawings shall govern.

The Contractor agrees to pay the Consultant **\$1.00, plus Applicable Taxes** for these electronic data. The fees noted are to cover the costs of preparation of the electronic data, and disbursements related to the preparation and shipment/forwarding of the electronic data only. By paying the fees quoted, the Contractor has in no way purchased the drawings or any rights to the drawings or the information contained therein, and the Contractor may only alter the drawings for the purposes noted above.

The electronic files will be provided in AutoCAD format (Version 2000 or more recent). The Consultant makes no representation as to the compatibility of these files with the Contractors hardware or software beyond the specified release of the referenced software.

The Contractor shall, to the fullest extent permitted by law, indemnify, defend and hold harmless the Consultant, and its sub-consultants from all claims, damages, losses, expenses, penalties and liabilities for any kind, including attorney's fees, arising out of, or resulting from the use of the electronic data by the Contractor, or by third party recipients of the electronic data from the Contractor.

The Consultant believes that no licensing or copyright fees are due to others on account of the transfer of the electronic media, but to the extent any are, the Contractor will pay the appropriate fees and hold the Consultant harmless from such claims.

Any purchase order number provided by the Contractor is for Contractor's accounting purposes only. Purchase order terms and conditions are void and are not part of this agreement.

The laws of the Province of Ontario shall govern this agreement.

The conditions and undertakings expressed wherein apply to partners, employees, agents, successors, assigns and legal or other representatives of the Contractor.

Dated at _____ this _____ day of _____, 20 ____.

Authorized Acceptance by Consultant

Signature

Print Name and Title _____

Date _____

By Contractor

Signature

Print Name and Title _____

Date _____

Common Work Results for Mechanical

EQUIPMENT START-UP AND ACCEPTANCE CHECK LIST																				
UNIT: LOCATION: MANUFACTURER: MOTOR MANUFACTURER: MOTOR NAMEPLATE: MODEL NO./TYPE: HORSEPOWER/kW: OVERLOAD HEATER/FUSES:	UNIT # SERIAL # SERIAL #																			
<div style="display: flex; justify-content: space-between;"> <div> PRE START-UP INSPECTION APPLICABLE) </div> <div> NOTES: (N/A, NOT </div> </div> POWER WIRING COMPLETE CONTROL WIRING COMPLETE INSTRUMENTATION INSTALLATION COMPLETE CHEMICAL TREATMENT ADDED BELT DRIVE TENSION ADJUSTED VERIFY LUBRICATION IS COMPLETE VERIFY VIBRATION ISOLATION IS COMPLETE VERIFY PROPER OVERLOAD HEATER/FUSE SIZES VERIFY ALIGNMENT MOTORS & DRIVES VERIFY PROPER DIRECTION OF ROTATION VERIFY LOCAL SAFETY & OPERATING CONTROL CHECK ABNORMAL/EXCESSIVE VIBRATION CHECK LEAKING PACKING GLANDS TEMPORARY STICKERS, TAGS, ETC. REMOVED																				
<table style="width: 100%; border: none;"> <thead> <tr> <th style="width: 60%;"></th> <th style="width: 20%; text-align: center;">DESIGN:</th> <th style="width: 20%; text-align: center;">ACTUAL:</th> </tr> </thead> <tbody> <tr> <td>VOLTAGE:</td> <td>PH 1:</td> <td>PH 1:</td> </tr> <tr> <td></td> <td>PH 2:</td> <td>PH 2:</td> </tr> <tr> <td></td> <td>PH 3:</td> <td>PH 3:</td> </tr> <tr> <td>AMPERAGE:</td> <td>PH 1:</td> <td>PH 1:</td> </tr> <tr> <td></td> <td>PH 2:</td> <td>PH 2:</td> </tr> </tbody> </table>				DESIGN:	ACTUAL:	VOLTAGE:	PH 1:	PH 1:		PH 2:	PH 2:		PH 3:	PH 3:	AMPERAGE:	PH 1:	PH 1:		PH 2:	PH 2:
	DESIGN:	ACTUAL:																		
VOLTAGE:	PH 1:	PH 1:																		
	PH 2:	PH 2:																		
	PH 3:	PH 3:																		
AMPERAGE:	PH 1:	PH 1:																		
	PH 2:	PH 2:																		
COMMENTS:																				
CHECKED BY	COMPANY	DATE																		
CHECKED BY	COMPANY	DATE																		
CHECKED BY	COMPANY	DATE																		
CHECKED BY	COMPANY	DATE																		
ACCEPTED BY	OWNER'S REP	DATE																		
ACCEPTED BY	CONSULTANT	DATE																		

END OF SECTION

PART 1 – GENERAL

1.1 Application

- .1 This Section specifies products, common criteria and characteristics, and methods and execution that are common to one or more mechanical work Sections of the Specification, and it is intended as a supplement to each Section and is to be read accordingly.

1.2 Submittals

- .1 Submit the following for review:
 - .1 shop drawings/product data sheets: submit for:
 - .1 pressure gauges and thermometers;
 - .2 electric motors (submit with equipment they are associated with).
 - .2 **access door locations:** submit white prints of architectural reflected ceiling plan drawings and elevation drawings to indicate proposed access door locations in walls and ceilings in finished areas;
 - .3 **samples:** submit a sample of each proposed type of access door, and samples of materials and any other items as specified in mechanical work Sections of the Specification;
 - .4 **list of equipment nameplates:** submit a list of equipment identification nameplates indicating proposed wording and sizes;
 - .5 **pipe & duct identification:** submit a list of pipe and duct identification colour coding and wording;
 - .6 **valve tag chart:** submit a proposed valve tag chart and a list of proposed valve tag numbering and identification wording;
 - .7 **waste management and reduction plan:** submit a waste management and reduction plan prior to commencing work and as per requirements specified in this Section;
 - .8 **drive belts:** as specified in Part 2 of this Section, submit a spare belt set, tagged and identified, for each belt driven piece of equipment;
 - .9 **additional submittals:** submit any other submittals specified in this Section or other mechanical work Sections of the Specification;

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 the sleeve to formwork construction.
- .2 Polyethylene: Factory fabricated, flanged, high density polyethylene sleeves with reinforced nail bosses.

- .3 Galvanized Steel or Cast-Iron Pipe: Schedule 40 mild galvanized steel, or Class 4000 cast iron.

2.2 Fire Stopping and Smoke Seal Materials

- .1 Design firestopping and smoke seals to maintain fire rating required in fire-rated walls and partitions; in all cavity wall construction at each floor level; in expansion joints where fire rating and/or fire separation is required; and elsewhere indicated.
- .2 Provide firestopping system in all joints, cut-outs around penetrations in the walls and floors and elsewhere required to ensure complete integrity of the fire rating prior to start of construction.
- .3 Provide seals to form draft tight barriers to retard the passage of flame, smoke, gas and firefighter's hose stream.
- .4 The installed seal shall provide and maintain a fire-resistance rating equivalent to the rating of the adjacent floor, wall or other fire separation assembly to the requirements and approval of authorities having jurisdiction.
- .5 Firestopping and smoke seals shall be ULC or Intertek Testing Services listed Products and systems in accordance with ULC-S115 suitable to actual application and installation conditions.
- .6 Firestop sealant: single component, low modulus, silicone rubber, moisture curing, ULC labelled to CAN/CGSB 19.13-M and ULC-S115.
- .7 Firestop insulation: to CAN/ULC-S702, Type 2; mineral fibre manufactured from rock or slag, suitable for manual application.
- .8 Density: 81 kg/m³ when tested to ASTM C303.
- .9 Combustibility: Non-combustible to CAN/ULC S114.
- .10 Melt temperature: >1175 degrees C.
- .11 Surface burning characteristics: to CAN/ULC S102, maximum flame spread of 0, smoke developed of 0.
- .12 Moisture Absorption: 0.04 percent when tested to ASTM C1104.
- .13 Smoulder Resistance: 0.01 percent when tested to CAN/ULC S129.
- .14 Damming, back-up, supports, and anchorage: In accordance with manufacturer's fire rated systems and to acceptance of authorities having jurisdiction.
- .15 Primer: As recommended by firestop sealant manufacturer.
- .16 Firestopping and smoke seals shall be ULC or Intertek Testing Services listed Products and systems in accordance with ULC-S115 suitable to actual application and installation conditions. All fire and smoke seals shall be 'L' rating.
- .17 Acceptable fire stop and smoke seal material manufacturers are 3M Canada Inc., Specified Technologies Inc. and A/D Fire Protection Systems and Hilti Canada.

2.3 Waterproofing Seal Materials

- .1 Modular, mechanical seal assemblies consisting of interlocking synthetic rubber links shaped to continuously fill the annular space between the pipe and the pipe sleeve or wall opening, assembled with stainless steel bolts and pressure plates and designed so that when the bolts are tightened the links expand to seal the opening watertight. The seal assemblies are to be selected to suit the pipe size and the sleeve size or wall opening size. Acceptable products are:
 - .1 Thunderline Corp. (Power Plant Supply Co.) "LINK SEAL" Model S-316;
 - .2 The Metraflex Co. "MetraSeal" type ES.

2.4 Pipe Escutcheon Plates

- .1 One-piece chrome plated brass or #4 finish type 302 stainless steel plates with matching screws for attachment to the building surface, each plate sized to completely cover the pipe sleeve or building surface opening, and to fit tightly around the pipe or pipe insulation.

2.5 Piping Hangers and Supports

- .1 General: Pipe hanger and support materials, including accessories, are to be, unless otherwise specified, in accordance with the Manufacturers Standardization Society (MSS) Standard Practice Manual SP-58, Pipe hangers and Supports-Materials, Design and Manufacture, and where possible, MSS designations are indicated with each product specified below. Conform to the following requirements:
 - .1 unless otherwise specified, all ferrous hanger and support products are to be electro-galvanized;
 - .2 hangers and supports for insulated piping are to be sized to fit around the insulation and the insulation jacket.
- .2 Horizontal Suspended Piping: Hangers and supports are to be:
 - .1 adjustable steel clevis hanger – Anvil Fig. 260 – MSS Type 1;
 - .2 adjustable swivel ring band type hanger – Anvil Fig. 69 – MSS Type 10;
 - .3 adjustable roller hanger – Anvil Fig's. 171, 177 & 181 – MSS Types 41, 43, and/or 45, with Anvil Fig. 160 to 166A – MSS Type 39 steel protection saddle
- .3 Horizontal Pipe On Vertical Surfaces: Epoxy coated steel pipe stays are not permitted. Supports are to be:
 - .1 steel offset pipe clamp – Anvil Fig. 103 or Myatt Fig. 170;
 - .2 heavy-duty steel pipe bracket – Anvil Fig. 262 or Myatt Fig. 161 – MSS Type 26;
 - .3 single steel pipe hook - Myatt Fig. 156;
- .4 Floor Supports For Vertical Risers: Supports are to be:
 - .1 copper tubing riser clamp – Anvil Fig. CT-121, Anvil Fig. CT-121C (plastic coated), or Myatt Fig. 150CT – MSS Type 8;
 - .2 heavy-duty steel riser clamp – Anvil Fig. 261, or Myatt Fig's. 182, 183, 190 and 191 – MSS Type 8.

- .5 Vertical Piping on Vertical Surfaces: Epoxy coated steel pipe stays are not permitted. Supports are to be:
 - .1 steel offset pipe clamp – Anvil Fig. 103 or Myatt Fig. 170;
 - .2 heavy-duty steel pipe bracket or soil pipe bracket – Anvil Fig. 262 or Myatt Fig. 161 – MSS Type 26;
 - .3 extension split pipe clamp – Anvil Fig's. 138R or Myatt Fig. 129 – MSS Type 12;
- .6 Horizontal Pipe On Racks: Unistrut or equal galvanized steel pipe racks with pipe securing hardware as follows:
 - .1 standard galvanized steel U-bolts/clamps supplied by the rack manufacturer;
 - .2 adjustable roller chair - Anvil Fig. 175 with Fig. 160-165 steel protection saddle.
- .7 Special Hangers and Supports: Special hangers and supports for various applications are as follows:
 - .1 **for groups of pipes having the same slope** – Anvil Fig. 195 welded steel brackets, Anvil Fig. 46 universal trapeze assemblies, or Unistrut or equal support assemblies, all with U-bolts, clamps, etc., to secure pipes in place;
 - .2 **for sections of piping connected to vibration isolated equipment** – hangers and supports as specified above but complete with MSS Type 48 spring cushions;
 - .3 **for piping on an existing roof** – Portable Pipe Hangers (Canada) Inc. "PP" Series prefabricated portable pipe support system components to suit the pipe, complete with all required accessories including bases, galvanized structural steel frames, and galvanized steel pipe hangers and/or supports conforming to MSS SP-58;
 - .4 **for natural gas and refrigeration piping on roof** – 'Quick Block' by Pipe-Ease Inc., assembled product tested and conforming to ASTM-D1708-02a for compression test and ASTM-D2990-01 for pull test, comprised of two major components:
 - .1 the support shell which is one-piece, UV resistant, thermoplastic injection moulded Polypropylene Impact Copolymer, designed with an interior web creating cavities to maximize support strength while substantially reducing the overall weight and allowing for expansion and contraction under extreme temperature conditions. Lower portion of the support shall incorporate $\frac{3}{4}$ " high wall which reduces UV exposure to the extruded polystyrene base;
 - .2 Type 3, 20 psi extruded polystyrene non-marring base in accordance with CAN/ULC-S701.
 - .5 **for plastic piping** – generally as specified above but in accordance with the pipe manufacturer's printed recommendations;
 - .6 **for fire protection piping** – generally as above but ULC listed and/or FM approved, and in accordance with Chapter requirements of the NFPA Standard applicable to the 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 the pipe from the clamp;
- .9 **insulation protection shields to & including 1½" dia.** – equal to Anvil "Rib-Lok" Fig. 168 galvanized steel shields with ribs to keep the shield centred on the hanger.
- .8 Hanger Rods: Electro-galvanized carbon steel (unless otherwise specified), round, threaded, to ASTM A36, complete with captive machine nuts with washers at hangers, sized to suit the loading in accordance with Table 3 in MSS SP-58, but in any case, minimum 3/8" diameter.
- .9 Acceptable Manufacturers: Acceptable hanger and support material manufacturers are:
 - .1 E. Myatt & Co. Inc.;
 - .2 Anvil International Inc.;
 - .3 Empire Tool & Mfg. Co. Inc.;
 - .4 Hunt Manufacturing Ltd.;
 - .5 Unistrut Canada Ltd.;
 - .6 Nibco Inc. "Tolco";
 - .7 Taylor Pipe Supports.

2.6 Access Doors

- .1 Prime coat painted steel (unless otherwise specified) flush access doors, each complete with a minimum #16 gauge frame, minimum #18 gauge door panel, heavy-duty rust-resistant concealed hinges, a positive locking screwdriver lock, and mounting and finishing features to suit the particular construction in which it is to be installed.
- .2 Access door sizes are to suit the concealed work for which they are supplied, and wherever possible they are to be of a standard size for all applications, but in any case, they are to be minimum 12" x 12" for hand entry and 24" x 24" for body entry.
- .3 Access doors in fire rated construction are to be ULC listed and labelled and of a rating to maintain the fire separation integrity.
- .4 Where access doors are located in surfaces where special finishes are required, they are to be of a recessed door type capable of accepting the finish in which they are to be installed so as to maintain the final building surface appearance throughout and constructed of stainless steel with a #4 finish.

2.7 Pressure Gauges and Thermometers

- .1 **Pressure Gauges:** Adjustable, glycerine filled, 4" or 4½" diameter, each accurate to within 1% of scale range and complete with a type 304 stainless steel case with relief valve and polished stainless steel bayonet, stainless steel rotary movement with stainless steel bushings and socket, a clear acrylic window, a dual scale white dial with a scale range such that the working pressure of the system is at the approximate mid-point of the scale, and black pointer. Acceptable products are:
 - .1 H. O. Trerice Co. Model 700 LFSS-40;
 - .2 Weiss Instruments Model LF4S-2;

- .3 Ashcroft #35-1009 SWL-26.
- .2 **Pressure Gauge Accessories & Additional Requirements:** Accessories and additional requirements are as follows:
 - .1 a bronze ball type shut-off valve is to be provided in the 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 each pressure gauge for steam piping or steam equipment is to be equipped with a steel coil syphon.
 - .4 pressure gauges in fire protection piping must be ULC listed and labelled.
 - .5 pressure gauges in laboratory gas piping systems are to conform to CSA Z7396.1 and are to be identified with the name of the service it is provided for as well as "USE NO OIL".
- .3 **Thermometers:** Round, 5" diameter, adjustable (90°) angle bimetal dial type thermometers, each accurate to within 1% of full scale and complete with a hermetically sealed stainless steel case with stainless steel ring, dampened bimetal coil, calibration adjustment screw, white aluminum dual scale dial with black and blue markings and a range such that the working temperature of the system is the approximate mid-point of the scale, black aluminum pointer, double strength glass window, 1/2" NPT connection with 1/4" diameter stainless steel stem, and a suitable thermowell. Acceptable products are:
 - .1 H.O. Trerice Co. B85600 Series;
 - .2 Weiss Instruments Model 5VBM25;
 - .3 Ashcroft #50EI60E-040-0/250.

2.8 Equipment Belt Drives

- .1 ANSI/RMA Standard V-belt type rated at minimum 1.5 times the motor nameplate rating, and in accordance with the 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 the 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 and hand to the Owner upon Substantial Performance of the work.

2.9 Equipment Drive Guards and Accessories

- .1 **For V-belt drives** - removable, four sided, fully enclosed, galvanized sheet steel guards to OSHA 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 the guard, and 1½" diameter tachometer openings at each shaft location.
- .2 **For flexible couplings** - removable "U" shaped galvanized steel guards to OSHA Standards with a 3/32" thick frame and expanded mesh face.
- .3 **For unprotected fan inlets & outlets** - unless otherwise specified, removable ¾" galvanized steel wire mesh with galvanized steel frames, all to OSHA Standards.

2.10 Electric Motors

- .1 Unless otherwise specified, motors are to conform to EEMAC 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 **Motor Efficiency:** The efficiency of single phase motors to 1 HP is to be in accordance with CAN/CSA C747. The efficiency of all three phase motors 1 HP and larger is to be in accordance with CAN/CSA C390 or IEEE 112B.
- .4 **Single Phase Motors:** Unless otherwise specified, motors smaller than ½ HP are to be 115 volt, continuous duty capacitor start type with an EEMAC 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 Single-Phase Motors:** Totally enclosed, fan cooled, 115-volt continuous duty capacitor start type in accordance with CSA C22.2 No. 145, as specified for standard single 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°C) ambient temperature.
- .6 **Three Phase Motors:** 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 the Drawings, EEMAC 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 1.5 service factor at 40°C ambient temperature, grease lubricated open ball bearings with grease fittings to permit re-lubrication without dismantling the 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 aluminium rotor windings.
- .7 **Explosion-Proof Three Phase Motors:** 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°C) ambient temperature.

- .8 **Thermistor Protection:** Unless otherwise indicated, motors 30 HP and larger are to be complete with a heat sensing PTC thermistor in the end turn of the stator winding for each phase and connected in series inside the motor with two marked leads brought out to the motor conduit box.
- .9 **Motors for VFD's:** 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 the 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.
- .10 **Corrosion Protection:** 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.
- .11 **Acceptable Manufacturers:** Acceptable motor manufacturers are:
 - .1 Westinghouse Canada Inc.;
 - .2 Canadian General Electric;
 - .3 Baldor Electric Co.;
 - .4 U.S. Electrical Motors;
 - .5 Weg Electric Corp.;
 - .6 Marathon Electric;
 - .7 Magna-Tech Canada;
 - .8 Toshiba Corp.;
 - .9 Leeson Canada.

2.11 Motor Starters and Accessories

- .1 General: All motor starters must be capable of starting the associated motors under the imposed loads. Confirm that starter voltage matches the motor prior to ordering.
- .2 Starters For Single Phase Motors: Unless otherwise specified, starters for single phase motors are to be 115 volt, thermal overload protected manual starting switches with a neon pilot light, a surface or recessed enclosure to suit the application, and, where automatic operation is required, a separate "hand-off-automatic" switch in an enclosure to match the starter enclosure.
- .3 Starters For Three Phase Motors Less Than 50 HP: Unless otherwise specified, starters for three 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 and overload relay per phase, an enclosure to suit the application, and, a "hand-off-automatic" switch, pilot lights, control transformer, auxiliary contacts, and other accessories as per the motor starter schedule.
- .4 Motor Starter Enclosures: Unless otherwise specified, motor starter enclosures are to be in accordance with the following NEMA/EEMAC ratings:
 - .1 all enclosures located in sprinklered areas – Type 2;

- .2 all enclosures exposed to the elements – Type 3R, constructed of stainless steel;
 - .3 all enclosures inside the building in wet areas – Type 3R, constructed of stainless steel;
 - .4 all enclosures in explosion rated area – Type 7 with exact requirements to suit the area and application;
 - .5 all enclosures except as noted above – Type 1;
 - .6 all enclosures located in finished areas – as above but recess type with brushed stainless steel faceplate.
- .5 Motor Control Centres: Multi-unit, 9' high, EEMAC Class 1, type "B", factory assembled, dead front, floor mounted, free-standing motor control centre with tin plated copper bus and an EEMAC 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 all required facilities for line and load side power wiring connections.
- .6 Disconnect Switches For Motor Control Centres: Heavy-duty, CSA certified, front operated switches as per the motor starter schedule, each complete with a handle suitable for padlocking in the "off" position and arranged so that the door cannot be opened with the handle in the "on" position and an EEMAC enclosure as specified for loose starters. Fusible units are to be complete with fuse clips to suit fuse types specified below.
- .7 Fuses: 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.
- .8 Acceptable Manufacturers: Acceptable manufacturers are:
- .1 Rockwell Automation Inc. - Allen-Bradley;
 - .2 Eaton Corp. – Cutler-Hammer;
 - .3 Eaton Corp. – Moeller Electric;
 - .4 Siemens Canada;
 - .5 Schneider Electric.

2.12 Mechanical Work Identification Materials

- .1 Equipment Nameplates: Minimum 1/16" thick 2-ply laminated coloured plastic plates, minimum 1/2" x 2" for smaller items such as damper motors and control valves, minimum 1" x 2 1/2" for equipment, and minimum 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 the equipment and its use with no abbreviations;
 - .2 wording is generally to be as per the drawings or UHN equipment naming convention, i.e. Fan 5-P-104, and is to include equipment service and building area/zone served, but must be reviewed 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: Coloured, 1½" square, 2-ply laminated plastic with bevelled edges, red-white, green-white, yellow-black, etc., to match the piping identification colour, each complete with a 1/8" diameter by 4" long brass plated steel bead chain, and four lines of engraved maximum size identification wording, i.e.:
 - .1 Valve V12
 - .2 8"
 - .3 Chill. Water
 - .4 Normally Open
- .3 Standard Pipe Identification: Standard pipe identification is to be in accordance with latest ANSI/ASME A13.1 "Scheme for the Identification of Piping Systems", equal to Smillie McAdams Summerlin Ltd. or Brady vinyl plastic with indoor/outdoor type vinyl ink lettering and directional arrows, as follows:
 - .1 for pipe to and including 6" diameter, coiled type snap-on markers of a length to wrap completely around the pipe or pipe insulation;
 - .2 for pipe larger than 6" diameter, saddle type strap-on markers with 2 opposite identification locations and complete with nylon cable ties.
- .4 Standard Pipe Identification Wording and Colours: Identification wording and colours for pipe identification materials shall match existing University of Toronto standards. Be responsible for obtaining and coordinating these standards with the University.
- .5 Colours for Legends & Arrows: Colours for pipe identification legends and directional arrows are to be as follows:

IDENTIFICATION COLOUR	LEGEND & ARROW COLOUR
red	white
orange	black
yellow	black
brown	white
green	white
blue	white
white	black

- .6 Duct Identification: Custom made Mylar stencils with 2" high lettering to accurately describe the 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 the lettering background.

2.13 Flexible Connectors

- .1 Double wall stainless steel flexible connectors for piping connections to vibration isolated equipment, each selected by the 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.

2.14 Pipe Freeze Protection Heating Cable

- .1 Raychem Canada Ltd. "XL-Trace-CR" or approved equal, CSA certified, self-regulating piping freeze protection cable sets as specified and/or scheduled on the drawings, each set complete with:
 - .1 the required lengths of "XL-TRACE" self-regulating heating cable;
 - .2 a power connection with end seal per circuit;
 - .3 tee connections with end seals as required for pipe branches;
 - .4 splice connections as required;
 - .5 GT-66 glass tape to secure cable on the pipe, and "Electric Traced" adhesive labels to be secured to pipe insulation;
 - .6 a pipe temperatures sensing thermostat.
- .2 Acceptable manufacturers are:
 - .1 Raychem Canada Ltd.
 - .2 Dimplex/Chromalox Inc.

2.15 Pipe Freeze Protection Cable Control

- .1 Raychem Canada Ltd. components as follows:
 - .1 snow sensor: Model CIT-1 or approved equal, 24 volt AC, roof or mast mounting, solid-state, microcontroller design aerial snow sensor to detect falling or blowing precipitation at 3.37°C (38°F) before snow or ice begins to accumulate;
 - .2 controller: Model APS-4C or approved equal, surface wall mounting controller with contactor and integral 30 mA ground fault circuit interrupter, test/reset facility, a relay interface for connection to a building management system, and an adjustable high temperature sensor to protect the heating cable from excessive temperature.
- .2 Acceptable manufacturers are:
 - .1 Raychem Canada Ltd.;
 - .2 Dimplex/Chromalox Inc.;
 - .3 Tyco Thermal Controls/Pyrotenax.

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 the ceiling on floors on which they are shown, arranged so that under consideration of all other work in the area, the maximum ceiling height and/or usable space is maintained. If required to maintain ceiling heights, reroute and/or resize ductwork, with Consultant's approval.
- .2 Unless otherwise specified, install all work concealed in finished spaces, and concealed to the degree possible in partially finished and unfinished spaces. Refer to and examine the Architectural drawings and room finish schedules to determine finished, partially finished, and unfinished areas. Note that walls which are painted are considered finished.
- .3 Install all pipes and ducts parallel to building lines and to each other.
- .4 Neatly group and arrange all exposed work.
- .5 Service and Maintenance Access: Locate all work to permit easy access for service or maintenance as required and/or applicable. Locate all valves, dampers and any other equipment which will or may need maintenance or repairs and which are 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 the accessories at the floor level.
- .6 Dissimilar Metal Pipe Connections: Make all connections between pipes of different materials using proper approved adapters. Provide cast brass dielectric type adapters/unions at connections between ferrous and copper pipe.
- .7 Manufacturer's Instructions: Ensure that equipment and material manufacturer's installation instructions are followed unless otherwise specified herein or on the drawings, and unless such instructions contradict governing codes and regulations.
- .8 Cleaning: Carefully clean all 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 Insulation Clearance: Install piping and ductwork which are to be insulated so that they have sufficient clearance to permit insulation and finish to be applied continuously and unbroken around the pipe or duct, except for ductwork at fire barriers, in which case the insulation will be terminated at each side of the duct fire damper.
- .10 Surfaces To Receive Your Work: Inspect surfaces and structure prepared by other trades before performing your work. Verify that surfaces or the structure to receive your work have no defects or discrepancies which could result in poor application or cause latent defects in installation and workmanship. Report defects in writing. Installation of your work will constitute acceptance of such surfaces as being satisfactory.
- .11 Piping Rust and Dirt: 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 the piping prior to being concealed.

- .12 Drain Pans: Provide continuous galvanized sheet metal drip pan under where indicated on the drawings and under all drain, water and water solution piping extending through all rooms with electrical equipment such as electrical, elevator equipment and transformer rooms, and all other spaces provided primarily for the installation of electrical equipment. Drip pans are to be complete with a drain pipe connection and drain piping is to be extended to the closest drain.
- .13 Repair of Finished Surfaces: For factory applied finishes, repaint or refinish all surfaces damaged during shipment and installation. The quality of the repair work is to match the original finish. This requirement also applies to galvanized finishes.
- .14 Work In High Humidity Areas: 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 the 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.
- .15 Unions and Flanges: Whether shown or specified on the drawings or not, provide screwed unions or flanges in all 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 Elbows and Eccentric Reducers: Unless otherwise specified and except where space limitations do not permit, all piping elbows are to be long radius. Eccentric reducers are to be installed with the straight side at the top of the piping.

3.2 Pipe Joint Requirements

- .1 Do not make pipe joints in walls or slabs.
- .2 Ream all piping ends prior to making joints.
- .3 Screwed Steel Piping: Properly cut threads in screwed steel piping and coat male threads only with Teflon tape or paste, or an equivalent thread lubricant. After the pipe has been screwed into the fitting, valve, union, or piping accessory, not more than two pipe threads are to remain exposed.
- .4 Welded Steel Piping: Site bevel steel pipe to be welded or supply mill bevelled pipe. Remove all scale and oxide from the bevels and leave smooth and clean. Use factory made welding tees or welding outlet fittings for piping branches off mains. Do not use shop or site fabricated fittings unless written approval has been obtained.
- .5 Welding Requirements: Welded joints are to be made by CWB certified, licensed journeyman welders qualified in accordance with CSA B51, Boiler Pressure Vessel and Pressure Piping Code, and who are in possession of a proper certificate of qualification for each procedure to be performed. Each weld is to be identified with the welder's identification symbol, and welds are not to be concealed until they have been inspected and approved. Electrodes are to be in accordance with CSA W48 Series, Electrodes, and requirements of CAN/CSA W117.2, Safety in Welding, Cutting and Allied Processes are to be followed.

- .6 Flanged Joints: Unless otherwise specified, make all flanged joints with Cranite Ltd. or equivalent gasket materials to suit the application, and bolts and nuts. Bolts are not to be longer than the length necessary to screw the nut up flush to the end of the bolt. Bolts used for flanged connections in all piping with a working pressure of 100 psi and greater are to be ASTM A-193, Grade B-7, with heavy hexagon nuts to ASTM A-194, CL-2H. Provide suitable washers between each bolt head and the flange and between each nut and the flange.
- .7 Examination of Flanged Joints: A random check of bolted flanged connections will be made to verify that flanged connections are properly mated with no shear force acting on bolts. Supply all labour to disconnect and reconnect the selected flanged joints. If improperly mated joints are found, remove and reinstall the affected piping so that the flanges mate properly. If improperly mated joints are found, additional joints will be checked, and you will be responsible for the repair of any other improper joints discovered.
- .8 Soldered Joints: Unless otherwise specified make all soldered joints in copper piping using flux suitable for and compatible with the type of solder being used. Clean the outside of the pipe end and the inside of the fitting, valve, or similar accessory prior to soldering.
- .9 Mechanical Joints: Install mechanical joint fittings and couplings in accordance with the manufacturer's instructions.
- .10 Grooved Pipe & Coupling Joints: Grooves are to be rolled. Make arrangements with the coupling and fitting manufacturer for shop and/or site instructions and demonstrations as required, and adhere to the manufacturer's instructions with respect to pipe grooving, support, type of gasket required, anchoring and guiding the grooved piping system.
- .11 Pressure Crimped Piping Joints: If pressure crimped couplings and fittings are used, ensure that gaskets are fully compatible with the piping fluid, and that all valves and piping accessories are suitable. Use only fitting manufacturer supplied crimping equipment. Comply with the manufacturer's latest published specification, instructions, and recommendations with respect to pipe, coupling, and fitting preparation and installation, and support, anchoring and guiding of the piping system.
- .12 PVC Piping Solvent Weld Joints: Solvent weld PVC piping in two parts, primer stage and cementing stage, in accordance with the manufacturer's recommendations, ASTM D2855, and CSA requirements.
- .13 PVC Piping Gasketed Joints: Install PVC piping with gasketed joints in accordance with the manufacturer's current published specifications, instructions and recommendations, and CSA requirements.

3.3 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 Waterproof Sleeves: Sleeves in waterproofed slabs or walls are to be lengths of Schedule 40 mild galvanized steel pipe with a waterstop plate in accordance with the drawing detail. Provide waterproof sleeves in the 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 all floors equipped with waterproof membranes;
 - .4 in the roof slab;
 - .5 in waterproof walls.
- .3 Size sleeves, unless otherwise specified, to leave ½" clearance around the pipes, or where the pipe is insulated, a ½" clearance around the pipe insulation.
- .4 Pack and seal the void between the pipe sleeves and the pipe or pipe insulation in non-fire rated construction for the length of the sleeves as follows:
 - .1 interior construction: pack sleeves in interior construction with mineral wool and seal both ends of the sleeves with non-hardening silicone base caulking compound;
 - .2 exterior walls above grade: pack sleeves in exterior walls above grade with mineral wool and seal both ends of the sleeves water-tight with approved non-hardening silicone base caulking compound unless mechanical type seals have been specified;
- .5 Where sleeves are required in masonry work, accurately locate and mark the sleeve location, and hand the sleeves to the mason for installation.
- .6 Terminate piping for sleeves that will be exposed so that the sleeve is flush at both ends with the building surface concerned so that the sleeve may be completely covered by an escutcheon plate, except for sleeves in waterproof floors which are to terminate 4" above the 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 the sleeved opening.

3.4 Installation of Waterproof Mechanical Seals

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

3.5 Installation of Pipe Escutcheon Plates

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

3.6 Installation of Fastening and Securing Hardware

- .1 Provide all fastening and securing hardware required for mechanical work to maintain installations attached to the structure or to finished floors, walls and ceilings in a secure and rigid manner capable of withstanding the dead loads, live loads, superimposed dead loads, and any vibration of the 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 the floor, wall or ceiling construction is not suitable to support the loads, provide additional framing or special fasteners to ensure proper securement to the structure that is to support the products. Provide reinforcing or connecting supports where required to distribute the loading to the structural components.
- .4 Obtain written consent before using explosive actuated fastening devices. If consent is obtained, comply with requirements of CSA Standards CAN3-Z166.1 and CAN3-Z166.2.
- .5 Do not attach fasteners to steel deck without written consent from the Consultant.

3.7 Installation of Pipe Hangers and Supports

- .1 Provide all 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 the structure only.
- .3 For Insulated Pipe: Size the hanger or support to suit the diameter of the insulated pipe and install the hanger or support on the outside of the insulation and insulation finish.
- .4 Horizontal Above Ground Piping: 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 shown or specified, hangers for suspended pipe to and including 1" dia. are to be clevis type or adjustable ring type, and hangers for suspended pipe 1½" dia. and larger are to be adjustable clevis type. Space hangers and supports in accordance with the following:
 - .1 cast iron pipe: hang or support at every joint with maximum 8' spacing;
 - .2 plastic pipe: conform to pipe manufacturer's recommended support spacing;
 - .3 copper and steel pipe: hang or support at spacing in accordance with the following schedule:

PIPE DIA.	MAX. SPACING STEEL (meters)	MAX. SPACING COPPER (meters)
to 1"	2.4 (8')	1.8 (6')
1½"	2.7 (9')	2.4 (8')
2"	3.0 (10')	2.7 (9')
2½"	3.6 (12')	3.0 (10')
3"	3.6 (12')	3.0 (10')
3½"	3.6 (12')	3.6 (12')
4"	4.2 (14')	3.6 (12')

- .4 flexible grooved pipe/coupling joint piping: as above but with not less than one hanger or support between joints;
- .5 changes in direction: where pipes change direction, either horizontally or vertically, provide a hanger or support on the horizontal pipe not more than 12" from the elbow, and where pipes drop from tee branches, support the tees in both directions not more than 2" on each side of the tee;
- .6 grouped piping: when pipes with the same slope are grouped and a common hanger or support is used, space the hanger or support to suit the spacing requirement of the smallest pipe in the group and secure pipes in place on the common hanger or support;
- .7 roller hangers & supports: provide roller hangers or supports for all heat transfer piping 2" diameter and larger 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 the pipe to protect the piping insulation.
- .5 Vertical Piping: Unless otherwise shown or specified, support vertical piping by means of supports specified in Part 2 of this Section, spaced in accordance with the following:
 - .1 support vertical pipes at maximum 3 m intervals or at every floor, whichever is lesser;
 - .2 for sections of vertical piping with a length less than 10', support the pipe at least once;
 - .3 for all vertical cast iron plain end pipe (mechanical joint type), secure the riser or pipe clamp around the pipe under a flange integral with the pipe for vertical support purposes, or provide a length of hub and spigot pipe to facilitate proper support;
 - .4 for all vertical steel pipe risers in excess of 10', weld shear lugs to the pipe to carry the load;
 - .5 for vibration isolated piping risers, provide rubber-steel-rubber vibration isolation pads between the riser clamps and the floor.

- .6 Piping on The Roof: 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 the schedule above and of a type to suit the application, and, for each support, carefully scrape away the roofing gravel, bed the support in a heavy covering of roofing mastic, then scrape the gravel back up around the support - secure pipes to supports;
- .7 Isolation for Bare Copper Tubing: Each hanger, support or securement for horizontal bare copper tubing is to be plastic coated to prevent direct contact between the pipe and the ferrous hanger. Each wall or floor clamp for vertical bare copper piping is to be isolated from the pipe by means of strips of flexible rubber inserts. The 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.
- .8 Insulation Protection Shields: For insulated horizontal piping to and including 1½" diameter, provide galvanized steel insulation protection shields between the insulation and the hanger or support. Install shields immediately after the pipe is insulated.
- .9 Pipe Support from Steel Deck: Do not support piping from steel deck without written consent from the Consultant.

3.8 Supply of Access Doors

- .1 Supply access doors to give access to all mechanical work which may need maintenance or repair but which is concealed in inaccessible construction, except as otherwise specified herein or on the drawings.
- .2 Locate access doors as inconspicuously as possible in walls and partitions and arrange mechanical work such that it is clearly within view and accessible for inspection and servicing, and to suit access door locations shown on the reviewed and approved white prints of reflected ceiling plan and elevation drawings submitted as per Part 1 of this Section.
- .3 Group piping and ductwork to ensure the minimum number of access doors is required. Access doors will be installed by the trades responsible for the particular type of construction in which the doors are required.
- .4 Submit a sample of each proposed access door for review prior to ordering.
- .5 Identify access doors supplied for concealed laboratory gas system shut-off valves or equipment with a permanent label in accordance with requirements of CAN/CSA Standard Z7396.1.

3.9 Installation of Valves

- .1 Generally, valve locations are indicated or specified on drawings or specified in Sections of the Specification where the valves are specified, however, regardless of locations shown or specified, the following requirements apply:
 - .1 provide shut-off valves to isolate all systems, at the base of all vertical risers, in branch take-offs at mains and risers on all floors, to isolate all 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 the discharge piping of each pump;
- .4 valve sizes are to be the same as the connecting pipe size;
- .5 valves are to be permanently identified with the size, manufacturer's name and figure number, and wherever possible, valves are to be the product of the same manufacturer;
- .6 the manufacturer's name, valve model or figure number, and the pressure rating are to be clearly marked on each valve;
- .7 for valves in insulated piping, the design of the valve stem, handle and operating mechanism is to be such that the insulation does not have to be cut or altered in any manner to permit valve operation.

3.10 Installation of Pressure Gauges and Thermometers

- .1 Pressure Gauges: Provide pressure gauges in the following locations:
 - .1 in valved tubing across the suction, suction strainer (if applicable), and discharge piping of each circulating pump;
 - .2 in the supply and return piping connections to main mechanical plant equipment such as main coils, etc.;
 - .3 in expansion tank(s);
 - .4 in separate domestic hot water instantaneous heater;
 - .5 at the 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 the meter;
 - .8 wherever else shown and/or specified on the contract documents or in the Specification.
- .2 Thermometers: Provide thermometers in the following locations:
 - .1 in supply and return piping connections to main mechanical plant equipment such as main coils, etc., unless temperature indication is supplied with the equipment;
 - .2 wherever else shown and/or specified herein or on the drawings.
- .3 Installation Requirements: Conform to the following installation requirements:
 - .1 for installation of thermometers in piping wells, provide a coat of metallic base heat transfer paste or grease in the piping well;
 - .2 for pressure gauges in piping at equipment locations, install the pressure gauge between the equipment and the first pipe fitting;
 - .3 locate, mount and adjust all 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.

3.11 Installation of Equipment Drive Guards and Accessories

- .1 Provide OSHA guards for all exposed accessible rotating parts such as belt drives, couplings, fan wheels, and shaft ends on all 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 the 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 the equipment but are not easily accessible for service, extend to an accessible location using aluminium or copper tubing.

3.12 Mechanical Work Identification

- .1 Exposed Piping & Ductwork: 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 20' (6 m) intervals on pipe and duct runs exceeding 6 m in length;
 - .6 at least once in each room, and at least once on pipe and duct runs less than 20' (6 m) in length.
- .2 Concealed Piping & Ductwork: Unless otherwise specified identify new concealed piping and ductwork as per Part 2 of this Section in locations as follows:
 - .1 at points where pipes or ducts enter and leave rooms, shafts, pipe chases, furred spaces, and similar areas;
 - .2 at maximum 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 Equipment: Provide an identification nameplate for each new piece of equipment, 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 all nameplates in the most conspicuous and readable location.

- .4 Motor Starters and Disconnect Switches: Provide an identification nameplate for each new motor starter or disconnect switch located in a motor control centre or on a motor starter panel, and on each individually mounted starter which you supply, and on each disconnect switch provided as part of the electrical work for motorized equipment which you provide.
- .5 Electrical Tracing: For all new electrically traced mechanical work, identification wording is to include "ELECTRICALLY TRACED".
- .6 Valve Tagging & Chart: Tag valves and prepare a valve tag chart in accordance with the following requirements:
 - .1 attach a valve tag to each new valve, except for valves located immediately at the equipment they control;
 - .2 prepare a computer printed valve tag chart to list all tagged valves, with, for each valve, the tag number, location, valve size, piping service, and valve attitude (normally open or normally closed);
 - .3 if an existing valve tag chart is available at the site, valve tag numbering is to be an extension of existing numbering and the new valve tag chart is to incorporate the existing chart;
 - .4 frame and glaze one copy of the chart and, unless otherwise directed, affix to a wall in each main Mechanical and/or Equipment Room;
 - .5 include a copy of the valve tag chart in each copy of the operating and maintenance instruction manuals;
 - .6 hand an identified and packaged (jewel case) compact disc of the valve tag chart to the Owner at the time the O & M Manuals are submitted.
- .7 Ceiling Tacks or Stickers: Where new 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 the ceiling panel material, or stickers equal to Brady "Quick Dot" on the ceiling grid material to indicate locations of the 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

3.13 Finish Painting of Mechanical Work

- .1 Touch-up paint all damaged factory applied finishes on mechanical work products.

3.14 Pipe Leakage Testing

- .1 Before new piping has been insulated or concealed, and before equipment, fixtures and fittings have been connected, test all piping for leakage.
- .2 Tests are to be witnessed by the Consultant and/or Owner's representative, and, where

required, representatives of governing authorities. Give ample notice 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 & Vent Piping: Securely close all openings and pipe ends and fill piping with water up to the highest level and ensure that the water stands at the same level for a minimum of two hours. After the fixtures and fittings are set and the pipes connected to the building drain or drains, turn on water into all pipe, fixtures, fittings and traps in order to detect any imperfect material or workmanship. Make a smoke test if required by the Municipality. At your option, drain and vent piping may be pressure tested with cold water at 50 psi (345 kPa) for two hours with zero leakage.
- .5 Domestic Water Piping: Test piping with cold water at a pressure of 1½ times normal working pressure and maintain the pressure for a minimum of two hours.
- .6 Sprinkler System Piping: Test all system piping in accordance with requirements of NFPA No. 13, "INSTALLATION OF SPRINKLER SYSTEMS", and in accordance with any additional requirements of governing authorities.
- .7 Heat Transfer (HVAC) System Piping: Test piping with cold water at a pressure of 150 psi (1035 kPa) for a minimum of two hours.
- .8 Steam & Condensate Piping: Test piping with cold water for a minimum of two hours at the following pressures:
 - .1 0 psi to 15 psi low pressure piping - 100 psi;
- .9 Compressed Air Piping: Test piping with dry compressed air or nitrogen 100 psi for a minimum of two hours. Test all piping joints with a water-soap solution while the piping is under pressure to detect leaks.
- .10 Refrigerant Piping: Test refrigerant piping for leakage and dehydrate in accordance with requirements of Chapter 18 of the ASHRAE HANDBOOK - FUNDAMENTALS.
- .11 General Re: All Testing: The following requirements apply to all testing:
 - .1 ensure that all piping has been properly flushed, cleaned and is clear of foreign matter prior to pressure testing;
 - .2 temporarily remove or valve off all piping system specialties or equipment which may be damaged by test pressures prior to pressure testing the systems, and flush piping to remove foreign matter;
 - .3 when testing is carried out below the highest level of the particular system, increase the test pressure by the hydrostatic head of 1 psi for every 24" below the high point;
 - .4 include for temporary piping connections required to properly complete the tests;
 - .5 piping under test pressure is to have zero pressure drop for the length of the test period;
 - .6 make tight leaks found during tests while the piping is under pressure, and if this is impossible, remove and refit the piping and reapply the 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 tests are to be done in reasonably sized sections so as to minimize the number of tests required;
- .9 in addition to the leakage tests specified above, demonstrate proper flow throughout the systems including mains, connections and equipment, as well as proper venting and drainage, and Include for any necessary system adjustments to achieve the proper conditions.

3.15 Supply of Motor Starters and Accessories

- .1 Unless otherwise shown or specified, supply a starter for each item of motorized equipment you provide. Refer to the drawing Motor Starter Schedule.
- .2 Three Phase Motor Starters In Motor Control Centres: Where three phase starters are indicated in motor control centres, supply the motor control centres with starters and bolt to a concrete housekeeping pad where shown.
- .3 Disconnect Switches In Motor Control Centres: Where package type equipment with integral starters, or equipment with starters integral in loose power and control panels supplied with the equipment is fed from a motor control centre, provide a disconnect switch in the motor control centre in lieu of a motor starter.
- .4 Motor Starter panels are shown/specified in the MMM Toronto office for grouping and mounting loose starters where the use of an MCC is not warranted.
- .5 Three Phase Motor Starters on Motor Starter Panels: Where three phase starters are indicated and/or scheduled to be mounted on a motor starter panel, the starters will be mounted and connected, complete with the panels and splitter trough, as part of the electrical work. Hand the starters to the electrical trade at the site when they are required.
- .6 Disconnect Switches on Motor Starter Panels: Where package type equipment with integral starters, or equipment with starters integral in loose power and control panels supplied with the equipment is fed from a motor starter panel, a disconnect switch will be provided on the motor starter panel as part of the electrical work
- .7 Single Phase Motor Starters: Unless otherwise specified or shown on the drawings, single phase motor starters will be mounted adjacent to the equipment they serve and connected complete as part of the electrical work. Hand the starters to the electrical trade at the site at the proper time.

3.16 Electrical Wiring Work for Mechanical Work

- .1 Unless otherwise specified or indicated, the following electrical wiring work for mechanical equipment will be done as part of the 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 the starters or disconnects to the equipment;
 - .2 "line" side power wiring to individual wall mounted starters, and "load" side wiring from the starters to the equipment;

- .3 "line" side power wiring to pre-wired power and control panels and variable frequency drives, and "load" side power wiring from the panels and VFD's to the equipment;
- .4 provision of receptacles for plug-in equipment;
- .5 provision of disconnect switches for all motors that are in excess of 30' from the starter location, or that cannot be seen from the starter location, and all associated power wiring;
- .6 all 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 provision of dedicated 120 volt, 15A-1P circuits terminated in junction boxes in mechanical equipment rooms for automatic control and building automation system wiring connections to be made as part of the automatic controls work;
- .9 120 volt power connections to electrical receptacles integral with small ceiling exhaust fans, including wiring through light switches or speed controllers;
- .10 120 volt wiring connections to lighting fixture/switch combinations integral with air handling units;
- .11 120 volt wiring connections to duplex receptacles integral with air handling unit control panels.
- .2 Mechanical wiring work not listed above or specified herein or on the drawings to be done as part of the electrical work is to be installed in conduit and is to be done as part of the mechanical work in accordance with wiring requirements specified for the electrical work.

3.17 Interruption to and Shut-Down Of Mechanical Services and Systems

- .1 Co-ordinate all shut-down and interruption to existing mechanical systems with the 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 a Contract, submit a list of anticipated shut-down times and their maximum duration.
- .3 Prior to each shut-down or interruption, inform the Owner and Consultant in writing 15 days in advance of the proposed shut-down or interruption and obtain written approval to proceed. Do not shut-down or interrupt any system or service without such written approval.
- .4 Perform work associated with shut-downs and interruptions as continuous operations to minimize the shut-down time and to reinstate the systems as soon as possible, and, prior to any shut-down, ensure that all materials and labour required to complete the work for which the shut-down is required are available at the site.
- .1 In general, where demolition will cause shutdown of services to areas which are to remain functional, it is expected that new work is to be roughed-in up to the point of final connections in order to minimize shutdowns. In many cases, this will require the need to run new services parallel to the existing services which are to be removed.

- .5 Pipe Freezing: Pipe freezing may be used to connect new piping to existing piping without draining the existing piping. Pipe freeze equipment is to be equal to "NORDIC FREEZE" equipment supplied by Mag Tool Inc. (1-800-661-9983).

- .1 Note that due to the age of some of the services within the existing buildings, shut-off valves may be seized or will not hold. Where connecting to existing hydronic piping, it is to be assumed that pipe freezing will be required.

3.18 Equipment Bases and Supports

- .1 Concrete Housekeeping Pads: Unless otherwise specified or required, set all floor mounted equipment on minimum 4" high reinforced concrete housekeeping pads 8" clear of the equipment on each side and end, or a minimum of 8" from the centreline of equipment anchor bolts to the edge of the base, whichever is larger. Conform to the 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 the concrete pour and be responsible for all required levelling, alignment, and grouting of the equipment;
 - .3 as a minimum, use wire mesh reinforcement, however, for pads for large heavy equipment, use reinforcement as per structural drawing details.
- .2 Structural Steel Stands/Supports: For equipment not designed for base mounting, where required, provide welded, cleaned and prime coat painted structural steel stands or supports conforming to the following requirements:
 - .1 all stands and supports, except those for small equipment, are to be designed by a structural engineer registered in the jurisdiction of the work, and stamped and signed design drawings with calculations are to be submitted as shop drawings for review;
 - .2 all steel stands are to be flange bolted to concrete housekeeping pads;
 - .3 all stands and supports are to be seismically restrained in accordance with applicable requirements.

3.19 Cutting, Drilling, and Patching for Mechanical Work

- .1 Do all cutting, drilling and patching of the existing building for the installation of your work. Perform all cutting and drilling with proper tools and equipment. Confirm the exact location of cutting and drilling with the Consultant prior to commencing the cutting and/or drilling work.
 - .1 This includes for all required mechanical work, inclusive of areas outside of the defined renovation and scope of work areas indicated on the architectural drawings.
- .2 Patch surfaces, where required, to exactly match existing finishes using tradesmen skilled in the particular trade or application worked on.
- .3 Where new pipes pass through existing construction, core drill an opening. Size openings to leave ½" clearance around the pipes or pipe insulation.

- .4 Prior to drilling or cutting an opening in poured concrete construction, determine the location, if any, of existing services concealed in the construction to be drilled or cut. Ferro Scan Test the walls or slabs if required.
- .5 You will be responsible for the repair of any damage to existing services, exposed or concealed, caused as a result of your cutting or drilling work.
- .6 Where drilling is required in waterproof slabs, size the opening to permit snug and tight installation of a pipe sleeve which is sized to leave ½" clearance around the pipe or pipe insulation. Provide a pipe sleeve in the opening. Pipe sleeves are to be Schedule 40 galvanized steel pipe with a flange at one end and a length to extend 4" above the slab. Secure the flange to the underside of the slab and caulk the void between the sleeve and slab opening with proper non-hardening silicone base caulking compound to produce a water-tight installation.

3.20 Packing and Sealing Core Drilled Pipe Openings

- .1 Pack and seal the void between the pipe opening and the pipe or pipe insulation for the length of the opening as follows:
 - .1 non-fire rated interior construction: pack openings in non-fire rated interior construction with mineral wool and seal both ends of the opening with non-hardening silicone base caulking compound to produce a water-tight seal;
 - .2 exterior walls above grade: pack sleeves in exterior walls above grade with mineral wool and seal both ends of the sleeves water-tight with approved non-hardening silicone base caulking compound unless mechanical type seals have been specified;
 - .3 exterior walls below grade: 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 below.

3.21 Excavation and Backfill Work

- .1 Do all excavation, backfill and related work required for your work. Perform such work in accordance with requirements of Division 2, except as modified by this Article. Examine the soil test report during the Tender period.
- .2 Grade the bottom of trench excavations as required.
- .3 In firm, undisturbed soil, lay pipes directly on the soil.
- .4 In rock and shale, excavate to 6" (150 mm) below and a minimum of 8" (200 mm) to either side of the pipe, and backfill to the required invert with granular "A" material compacted to minimum 95% Standard Proctor Density.
- .5 Prepare new bedding under pipe in unstable soil, in fill, and in all cases where pipe bedding has been removed in earlier excavation, particularly near perimeter walls and at manholes and catch basins. Compact to maximum possible density and support the pipe by 8" (200 mm) thick reinforced concrete cradles spanning full length between firm supports. Install reinforcing steel in the cradles or construct piers every 7.87' (2.4 m) or closer, down to solid load bearing strata. Provide a minimum of one (1) pier per length of pipe. Use the same method where pipes cross.

- .6 Where excavation is necessary in proximity to and below the level of any footing, backfill with 2,000 psi (13,800 kPa) concrete to the level of the highest adjacent footing. Proximity is determined by the angle of repose as established by the Consultant.
- .7 Provide support over at least the bottom one-third (1/3) segment of the pipe in all bedding methods. Shape the excavation to fit pipe hubs, couplings and similar items and ensure even bearing along the barrels.
- .8 Keep walls of trenches straight to at least 18" (450 mm) within the pipe design limits. Have excavations inspected at least once a week by authorities. Break-up rocks and boulders and remove these by drilling and wedging. Do not use blasting specifically approved by the Consultant.
- .9 Before backfilling, test work for leakage and arrange for the work to be inspected by the Consultant. Remove all shoring during backfilling.
- .10 Backfill trenches within the building with clean sharp sand in individual layers of maximum 6" (150 mm) thickness compacted to a density of 100% Standard Proctor. Hand compact the first layers up to a compacted level of minimum 12" (300 mm) above the top of the pipe. Hand or machine compact the balance up to grade.
- .11 Backfill trenches outside the building (not under roads, parking lots or traffic areas), up to a compacted level of 18" (450 mm) thick above the pipe with granular "A" material hand compacted to a density of 95% Standard Proctor. Backfill the balance in 6" (150 mm) layers with approved excavated material, compacted to 95% Standard Proctor density.
- .12 Backfill trenches outside the building under roads, parking lots or traffic areas with 1/4" (7 mm) crushed stone or granular "A" gravel in layers not exceeding 6" (150 mm) thickness, compacted to 100% Standard Proctor density up to grade level.
- .13 Do not use water for consolidated or during compaction of backfill.
- .14 Fill all depressions to correct grade level with appropriate material, after an adequate period has passed to reveal any settlement. Use maximum possible compaction. Pay all costs required to make good all damage caused by settlement.
- .15 Dispose of surplus excavated materials as specified in Division 2.
- .16 Do pumping as required to keep excavations free of water.
- .17 The inverts and locations of existing site services shown on the drawings are approximate and it is your responsibility to confirm and satisfy yourself that the inverts and locations as shown are correct, prior to commencing work. Where discrepancies are found, immediately inform the Consultant and await a direction.
- .18 Note: You will be held responsible for any damage done to existing underground services caused by neglect to determine and mark out the location of such services prior to excavation work commencing.
- .19 Ensure that all underground water and drainage piping outside the building has a minimum of 4'-6' (1.37 m) of cover.
- .20 Ensure that all underground water and drainage piping inside the building in unheated areas has a minimum of 18" (450 mm) of cover.

- .21 Engage the services of an independent Soils Testing Agency to test the final backfill compaction density of each backfilled location. Ensure backfill is compacted to the satisfaction of the Testing Agency and in accordance with the Specification. Prior to applying for a Certificate of Substantial Completion of the Work, submit copy of Testing Agency's report to the Consultant for review. Include a copy of the report in each operating and maintenance instruction manual.

3.22 Instructions to Owner

- .1 Instruct the Owner's designated representatives in all aspects of the operation and maintenance of mechanical systems and equipment.
- .2 Arrange and pay for the services at the site, for the length of time required, of qualified technicians and other manufacturer's representatives to instruct on specialized portions of the installation.
- .3 Submit, prior to Substantial Performance, a complete list of systems for which instructions were given, stating for each system:
 - .1 date instructions were given to the Owner's staff;
 - .2 duration of instruction;
 - .3 names of persons instructed;
 - .4 other parties present (manufacturer's representatives, etc.);
- .4 Obtain the signatures of the Owner's staff to verify they properly understood the system installation, operation and maintenance requirements and have received operating and maintenance manuals and record drawings.

3.23 Cleaning Mechanical Work

- .1 Refer to cleaning requirements specified in Division 01.
- .2 Clean all mechanical work prior to application for Substantial Performance of the Work.

3.24 Maintaining Equipment Prior to Acceptance

- .1 Maintain all equipment in accordance with the manufacturer's printed 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.

3.25 Connections to Other Equipment

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

3.26 Waste Management and Disposal

- .1 Separate and recycle waste materials in accordance with requirements specified in Division 01.

3.27 Installation of Flexible Connectors

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

3.28 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.

3.29 Fire Stopping

- .1 Ensure that fire ratings of floors and walls are maintained.
- .2 Fill spaces between openings, pipes and ducts passing through fire separations and install firestopping systems in accordance with the appropriate ULC system number for the products and type of penetration.
- .3 Install firestopping systems using personnel trained or instructed by the product manufacturer.

3.30 Freeze Protection Cable

- .1 Provide electric tracing cable sets to prevent piping from freezing where shown.
- .2 Clearly identify the piping to be traced. Ensure that the piping has been pressure tested prior to cable installation and that the manufacturer's installation instructions are observed.
- .3 After cable installation but before the application of piping insulation, megger test and commission cable in the presence of the Consultant and in accordance with the cable manufacturer's printed installation and operation manual. Replace any damaged or faulty cable, and when satisfactory results have been obtained, submit signed test reports to the Consultant.
- .4 When traced piping has been insulated, install "Electrically Traced" labels on opposite sides of the pipe at 3 m (10') intervals.
- .5 When cable installations are complete, check and test operation of each cable set with the heater manufacturer's representative, make any required adjustments, and have the cable manufacturer certify in writing that the cable sets have been properly installed and operate as intended.
- .6 Provide a list of all heat trace cable installations including Tag and Maintenance manuals, numbers, model number, location and application in MS Excel Format. List to be provided in Operations.

END OF SECTION

PART 1 - GENERAL

1.1 Application

- .1 This Section specifies vibration isolation product 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 Submittals

- .1 **Product Data:** Submit shop drawings for all devices specified herein and as indicated and scheduled on the drawings. Submittals shall indicate full compliance with the device specification in Part 2. Any deviation shall be specifically noted and subject to engineer approval. Submittals shall include device dimensions, placement, attachments and anchorage requirements. Shop Drawings shall include the following:
 - .1 Vibration Isolation Bases: Dimensional drawings including anchorage and attachments to structure and to supported equipment, if needed or required. Include auxiliary motor slides and rails, base weights, equipment static loads.
 - .2 Vibration Restraint Details: Detailed submittal drawings of vibration restraints and snubbers. Show anchorage details and indicate quantity, diameter, and depth of penetration of anchors. Include ratings for loads.

1.3 Manufacturer's Certification Letter

- .1 Submit a letter from the vibration isolation manufacturer to certify correct installation of his products, as specified in Part 3 of this Section.

PART 2 - PRODUCTS

2.1 General

- .1 Vibration isolation products are to be in accordance with the drawing schedule and details, and as specified below.
- .2 **Springs:** All springs are to be stable, colour coded, selected to operate at no greater than $\frac{2}{3}$ solid load, designed in accordance with the Society of Automotive Engineers Handbook Supplement 9 entitled Manual on Design and Application of Helical and Spiral Springs, and with spring diameters in accordance with the manufacturer's recommendations to suit the static deflection and maximum equipment load.
- .3 **Finishes:** All steel components of isolation products not exposed to the weather or moisture are to be zinc plated. All steel components of isolation products exposed to the weather or in a damp, moist environment are to be factory painted with rust inhibiting primer and two coats of neoprene.
- .4 Where the weight of isolated equipment may change significantly due to draining or filling with a liquid, vibration isolators are to be equipped with limit stops to limit spring extensions.
- .5 **Flexible Piping Connections:** Flexible piping connections to vibration isolated equipment are specified in the appropriate piping sections of the Specification.

2.2 Isolation Pads

- .1 Sandwich type pads, 20 mm ($\frac{3}{4}$ ") nominal thickness, selected for 3.2 mm ($\frac{1}{8}$ ") static deflection unless otherwise specified, consisting of two waffle type or ribbed 50 durometer neoprene pads permanently bonded to a minimum #10 gauge steel plate, and complete with rubber bushed bolt holes and equipment anchor bolts with neoprene isolation grommets. Acceptable products are:

- .1 Kinetics Noise Control Vibron Products Group Type NGS/NGD;
- .2 Vibro-Acoustics Ltd. Type NSN;
- .3 Mason Industries Inc. Type SW/S/SW with HG Bolt Insertion Washers;

2.3 Rubber Floor Isolators

- .1 Captive, bridge bearing quality neoprene mount selected for a minimum 4 mm (0.15") static deflection unless otherwise specified, with an integral ductile iron housing and integral equipment anchor bolt. Acceptable products are:

- .1 Kinetics Noise Control Vibron Products Group Type RQ;
- .2 Vibro-Acoustics Ltd. Type R;
- .3 Mason Industries Inc. Type BR;

2.4 Open Spring Mounts

- .1 Base mount free-standing assemblies, each complete with a stable colour coded steel spring welded in place, drilled mild steel mounting plate bonded to a ribbed rubber or neoprene acoustical pad, and an external 16 mm ($\frac{5}{8}$ ") diameter level adjustment bolt. Acceptable products are:

- .1 Kinetics Noise Control Vibron Products Group Type FDS;
- .2 Vibro-Acoustics Ltd. Type FS;
- .3 Mason Industries Inc. Type SLFH.

2.5 Totally Retained Spring Mounts

- .1 Base mount free-standing enclosed and retained assemblies to limit both vertical and lateral movement of the mounted equipment, each complete with stable colour coded spring(s), drilled welded steel housing and top plate, ribbed rubber or neoprene acoustical pad bonded to the bottom of the housing, vertical limit adjusting hardware, and a level adjustment bolt. Acceptable products are:

- .1 Kinetics Noise Control Vibron Products Group Type SM;
- .2 Vibro-Acoustics Ltd. Type CSR;
- .3 Mason Industries Inc. Type SLRSO.

2.6 Spring Hangers

- .1 Welded steel plate housing with top and bottom rod mounting holes and spring retainer, neoprene double deflection isolation element, stable colour coded spring, and heavy-duty rubber washers. Acceptable products are:

- .1 Kinetics Noise Control Vibron Products Group. Type SRH;
- .2 Vibro-Acoustics Ltd. Type SHR-SN;

- .3 Mason Industries Inc. Type 30N.

2.7 Neoprene Hanger Isolators

- .1 Neoprene double deflection rod isolators with steel housing and hanger rod bushing, selected for a minimum 4 mm (0.15") static deflection unless otherwise specified. Acceptable products are:
 - .1 Kinetics Noise Control Vibron Products Group Type RH;
 - .2 Vibro-Acoustics Ltd. Type NH;
 - .3 Mason Industries Inc. Type HD or WHD.

2.8 Steel Equipment Base

- .1 Fully welded structural steel equipment and motor support bases, each complete with a wide flange steel frame, full depth cross members, brackets for spring mounts, and adjustable motor slide rails. Acceptable products are:
 - .1 Kinetics Noise Control Vibron Products Group Type SFB;
 - .2 Vibro-Acoustics Ltd. Type SB;
 - .3 Mason Industries Inc. Type WFSL.

PART 3 - EXECUTION

3.1 Installation of Vibration Isolation Materials

- .1 Provide vibration isolation products for mechanical work in accordance and requirements specified herein and/or on the drawings.
- .2 At a minimum, vibration isolation shall be provide for mechanical equipment as recommended in "Table 47. Selection Guide for Vibration Isolation" in Chapter 48 of the *ASHRAE Handbook*.
- .3 Supply to the vibration isolation product manufacturer or supplier a copy of a "reviewed" shop drawing or product data sheet for each piece of equipment to be isolated and dimensioned pipe layouts of associated piping to be isolated.
- .4 Unless otherwise specified, all vibration isolation products are to be the product of one manufacturer.
- .5 Ensure that the vibration isolation manufacturer coordinates material selections with equipment provided in order to ensure adherence to performance criteria. Allow for expansion and contraction when material is selected and installed.
- .6 **Isolation of Piping:** Isolate all piping larger than 25 mm (1") dia. directly connected to motorized and/or vibration isolated equipment with 25 mm (1") static deflection spring hangers at spacing intervals in accordance with the following:
 - .1 for pipe to and including 100 mm (4") dia. – first three points of support;
 - .2 for pipe 125 mm (5") to 200 mm (8") dia. – first four points of support;
 - .3 for pipe 250 mm (10") dia. and larger – first six points of support;
 - .4 the first point of isolated piping support is to have a static deflection of twice the deflection of the isolated equipment but maximum 50 mm (2");

- .5 secure the top of the spring hanger frame rigidly to the structure, and do not install spring hangers in concealed locations;
- .6 where it is impossible to use at least two spring hangers, provide Senior Flexonics Ltd. Style 102 (or 102-U as required) or equal, twin sphere, moulded rubber flexible connection assemblies, selected by the manufacturer and suitable in all respects for intended application, and complete with required nipples and connections to provide proper vibration isolation.
- .7 **Piping Risers:** Isolate designated piping risers at floor support points in accordance with the drawing detail.
- .8 **Control Wiring Connections:** For all control wiring connections to vibration isolated equipment ensure that flexible metallic conduit with 90° bend is used for conduit 25 mm (1") dia. and smaller, and for conduit larger than 25 mm (1") dia., use Crouse Hinds EC couplings. Connections are to be long enough so that the conduit will remain intact if the equipment moves 300 mm (12") laterally from its installed position, and flexible enough to transmit less vibration to the structure than is transmitted through the vibration isolation. Coordinate these requirements with the mechanical trades involved. If electrical power connections are not made in a similar manner as part of the electrical work, report this fact to the Consultant.
- .9 **Manufacturer's Inspection & Certification:** Arrange and pay for the vibration isolation product manufacturer to visit the site to inspect installation of his equipment. Do any revision work required as a result of improper installation. When the vibration isolation equipment manufacturer is satisfied with the installation, obtain and submit a letter stating that he has inspected the installation and that his equipment is properly installed.

END OF SECTION

PART 1 - GENERAL

1.1 Application

- .1 This Section specifies insulation 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.
- .2 Refer to the article entitled "Additional Insulation Work Required" in Part 3 of this Section for additional insulation work requirements outside of the scope of this project.

1.2 Submittals

- .1 **Insulation System Samples:** At least four weeks prior to insulation work commencing, submit a sample of each type of insulation (and insulation accessories and finish), in applied form, for approval. Mount the samples on a plywood board. Identify each product with the manufacturer's name and insulation type, and the proposed use of the insulation. When the sample board has been approved, all mechanical insulation work is to conform to the approved sample board.
- .2 **Product Data Sheets:** Submit a product data sheet for each insulation system product.
- .3 **Removable/Reusable Insulation Covers:** Submit a fabrication drawing for each custom made cover to indicate material and fabrication details, and a 300 mm (12") square sample of the proposed cover material.
- .4 **Fire Rated Duct Wrap Certification Letter:** As per Part 3 of this Section, submit a letter from the fire rated duct wrap supplier to certify that the duct wrap has been properly installed.
- .5 **Lagging Adhesive Colour Samples:** Submit a colour chart for coloured lagging adhesive for canvas jacketed insulation.

1.3 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 that all surfaces to be insulated are clean and dry.
- .4 Ensure that the ambient temperature is minimum 13°C (55°F) for at least one day prior to the application of insulation, and for the duration of insulation work, and that relative humidity is and will be at a level such that mildew will not form on insulation materials.
- .5 The company with the sub-contract for mechanical insulation work is to be a member in good standing of the Thermal Insulation Association of Canada.
- .6 All insulation materials must be stored on site in a proper and dry storage area. Any wet insulation material is to be removed from the site.

1.4 Definitions

- .1 For the work of this Section:

- .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, rock wool, and slag wool;
- .4 "domestic water" or "potable water" means all piping extended from the building Municipal supply main.

PART 2 - PRODUCTS

2.1 Fire Hazard Ratings

- .1 Unless otherwise specified, all insulation system materials inside the 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 CAN/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 the values given in Tables 6.8.2.A, 6.8.2.B, 6.8.3.A and 6.8.3.B of ASHRAE/IES Standard 90.1.

2.3 Pipe Insulation Materials

- .1 **Horizontal Pipe Insulation at Hangers & Supports:** Equal to Belform Insulation Ltd. "Koolphen K-Block" insulated pipe support inserts consisting of minimum 150 mm (6") long, premoulded, 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:** 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 E96-90, Procedure B, and all required installation accessories. Acceptable products are:
 - .1 Armacell AP/Armaflex SS;
 - .2 IK Insulation Group K-Flex "LS" Self-Seal Pipe Insulation.
- .3 **Premoulded Mineral Fibre:** Rigid, sectional, sleeve type insulation to ASTM Standard C 547-00, with a factory applied vapour barrier jacket. Acceptable products are:
 - .1 Johns Manville Inc. "Micro-Lok AP-T Plus";
 - .2 Knauf Fiber Glass "Pipe Insulation" with "ASJ-SSL" jacket;
 - .3 Manson Insulation Inc. "ALLEY K APT";
 - .4 Owens Corning Fiberglas Pipe Insulation.

- .4 **Blanket Mineral Fibre:** Blanket type roll insulation to CGSB 51-GP-11M, 24 kg/m³ (1½ lb./ft.³) density, with a factory applied vapour barrier facing. 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.

2.4 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 the lavatory. Acceptable products are:
 - .1 Truebo "Lav-Guard 2" E-Z Series;
 - .2 Zeston "SNAP-TRAP";
 - .3 McGuire Manufacturing Co. Inc. "ProWrap".

2.5 Equipment Insulation Materials

- .1 **Blanket Mineral Fibre:** Blanket type roll form insulation to ASTM Standard C553-00, 24 kg/m³ (1½ lb./ft.³) density, with a factory applied vapour barrier facing. 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:** Roll form, moulded insulation to ASTM Standard C1393-00a, with a factory applied vapour barrier facing consisting of laminated aluminum foil and kraft paper. 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;
 - .6 Glass-Cell Fabricators Ltd. "R-Flex".
- .3 **Semi-Rigid Mineral Wool Blanket:** Equal to Roxul "Enerwrap80" flexible, black fibrous scrim faced mineral wool blanket insulation to ASTM C 553.
- .4 **Closed Cell Foamed Glass:** Pittsburgh Corning "FOAMGLAS" expanded, rigid board and block type insulation with a liquid or vapour permeability rating (as per ASTM C240) of 0.00.

2.6 Removable/Reusable Insulation Covers

- .1 **Valve, Etc., Covers:** NO SWEAT reusable insulation wraps with vapour barrier jacket and self-sealing ends and longitudinal seam, with a length to suit the application and an insulation thickness equal to the adjoining insulation.
- .2 **Equipment Covers:** Custom manufactured covers conforming to the shape of the item to be insulated, designed to be easily removable and replaceable to suit the use and maintenance procedures of the particular item, and to provide adequate personnel protection. Covers are to be complete with minimum 95 kg/m³ (6 lb./ft.³) density ceramic fibre insulation sewn between minimum 542.5 g/m² (1.8 oz./ft.²) weight silicone impregnated fibreglass fabric in a quilted pattern using double stitches made with Kelvar or Teflon coated fibreglass thread. Overlap flaps are to be secured using laces, snaps, or Velcro double stitched in place. Acceptable manufacturers are:
 - .1 Cossby Dewar Inc.;
 - .2 Insufab Systems Inc.;
 - .3 ADL Insulflex Inc.;
 - .4 Firwin Corp.;
 - .5 Glass Cell Isofab Inc.

2.7 Ductwork System Insulation Materials

- .1 **Rigid Mineral Fibre Board:** Preformed board type insulation to ASTM C612-00a, 48 kg/m³ (3.0 lb./ft.³) density, with a factory applied reinforced aluminum foil and kraft paper facing. Acceptable products are:
 - .1 Knauf Fiber Glass Insulation Board with FSK facing;
 - .2 Manson Insulation Inc. "AK BOARD FSK";
 - .3 Johns Manville Inc. Type 814 "Spin-Glas";
 - .4 Owens Corning 703.
- .2 **Semi-Rigid Mineral Fibre Board:** Roll form insulation to ASTM Standard C1393 00a, consisting of cut strips of rigid mineral board insulation glued to an aluminium foil and kraft paper facing. Acceptable products are:
 - .1 Multi-Glass Insulation Ltd. "Multi-Flex MKF";
 - .2 Glass-Cell Fabricators Ltd. "R-FLEX";
 - .3 Owens Corning Pipe and Tank Insulation;
 - .4 Johns Manville Inc. Pipe and Tank Insulation.
- .3 **Blanket Mineral Fibre:** Blanket type roll form insulation to ASTM Standard C553-00, 24 kg/m³ (1½ lb./ft.³) density, 40 mm (1½") thick, with a factory applied vapour barrier facing. 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 Sheet:** 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. Acceptable products are:

- .1 Armacell "AP/Armaflex SA";
- .2 IK Insulation Group "K-Flex Duct Wrap", S2S.

2.8 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".

2.9 Insulation Fastenings

- .1 **Wire:** Minimum #15 gauge galvanized annealed wire.
- .2 **Wire Mesh:** Minimum #15 gauge galvanized annealed wire factory woven into 25 mm (1") hexagonal mesh.
- .3 **Aluminium Banding:** Equal to ITW Insulation Systems Canada "FABSTRAPS" minimum 12 mm (½") wide, 0.6 mm (1/16") thick aluminium strapping.
- .4 **Stainless Steel Banding:** Equal to ITW Insulation Systems Canada "FABSTAPS" 0.6 mm (1/16") thick, minimum 12 mm (½") wide type 304 stainless steel strapping.
- .5 **Duct Insulation Fasteners:** Weld-on 2 mm (3/32") diameter zinc coated steel spindles of suitable length, complete with minimum 40 mm (1½") square plastic or zinc plated steel self-locking washers.
- .6 **Tape Sealant:** Equal to MACtac Canada Ltd. self-adhesive insulation tapes, types PAF, FSK, ASJ, or SWV as required to match the surface being sealed.
- .7 **Adhesive - Mineral Fibre Insulation:** Clear, pressure sensitive, brush consistency adhesive, suitable for a temperature range of -20°C to 82°C (-4°F to 180°F), compatible with the type of material to be secured, and WHMIS classified as non-hazardous.
- .8 **Adhesive – Flexible Elastomeric Insulation:** Armacell "Armaflex" #520 air-drying contact adhesive.
- .9 **Lagging Adhesive:** White, brush consistency, ULC listed and labelled, 25/50 fire/smoke rated lagging adhesive for canvas jacket fabric, suitable for colour tinting, complete with fungicide and washable when dry.
- .10 **Sheet Metal Screws:** No. 10 stainless steel sheet metal screws.

2.10 Insulation Jackets and Finishes

- .1 **Canvas:** ULC listed and labelled, 25/50 rated, roll form, minimum 170 g (6 oz.) canvas jacket material.
- .2 **White PVC:** Roll form sheet and fitting covers, minimum 15 mil thick white PVC, 25/50 rated, complete with installation and sealing accessories. Acceptable products are:
 - .1 Proto Corp. "LoSMOKE";

- .2 The Sure-Fit System "SMOKE-LESS 25/50";
- .3 Johns Manville Inc. "Zeston" 300.
- .3 **Rigid Aluminium:** Equal to ITW Insulation Systems Canada "Lock-on" 0.406 mm (0.016") thick embossed aluminum jacket material to ASTM B209, factory cut to size and complete with polysurlyn moisture barrier and continuous modified Pittsburgh Z-Lock, and "Fabstraps" and butt straps with weatherproof the end to end joints. Fittings are to be two-piece epoxy coated pressed aluminum with weather locking edges.
- .4 **Stainless Steel:** Equal to ITW Insulation Systems Canada "Lock-on" 0.254 mm (0.010") thick type 304 embossed stainless steel to ASTM A240, factory cut to size and complete with moisture barrier and continuous modified Pittsburgh Z-Lock, and butt straps with "Fabstraps" to cover end to end joints. Fittings are to be two piece pressed stainless steel with weather locking edges.
- .5 **Adhesive Backed Flexible Aluminium:** 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 aluminum facing.
- .6 **Protective Coating - Flexible Foam Elastomeric Insulation:** Equal to Armacell "WB Armaflex" weatherproof, water-based latex enamel finish.

PART 3 - EXECUTION

3.1 General Insulation Application Requirements

- .1 Unless otherwise specified, do not insulate the 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 the 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;
 - .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 flexible branch ductwork from sheet metal ducts to grilles or diffusers;
 - .12 fire protection system water storage tanks;
 - .13 piping unions, except for unions in "cold" category piping.

- .2 Install insulation directly over pipes and ducts and not over hangers and supports.
- .3 Install piping insulation and jacket continuous through pipe openings and sleeves.
- .4 Install duct insulation continuous through walls, partitions, and similar surfaces except at fire dampers.
- .5 When insulating "cold" piping and equipment, extend insulation up valve bodies and other such projections as far as possible, and protect the insulation jacketing from the action of condensation at its junction with the metal.
- .6 Insulate, vapour seal, and finish all 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 the adjacent pipe or equipment finish, to match the piping and/or equipment insulation.
- .7 When insulating vertical piping risers 75 mm diameter and larger, use insulation support rings welded directly above the lowest pipe fitting, and thereafter at 4.5 m centres and at each valve and flange. Insulate as per Thermal Insulation Association of Canada National Insulation Standards, Figure No. 9.
- .8 Where piping and/or equipment is traced with electric heating cable, ensure that the cable has been tested and accepted prior to the application of insulation, and ensure that the cable is not damaged or displaced during the application of insulation.
- .9 Where existing insulation work is damaged as a result of a new mechanical work, repair the damaged insulation work to new work standards.
- .10 Where mineral fibre rigid sleeve type insulation is terminated at valves, equipment, unions, etc., neatly cover the exposed end of the insulation with a purpose made PVC cover on "cold" piping, and with canvas jacket material on "hot" piping.
- .11 Carefully and neatly gouge out insulation for proper fit where there is interference between weld bead, mechanical joints, etc., and insulation. Bevel away from studs and nuts to permit their removal without damage to insulation, and closely and neatly trim around extending parts of pipe saddles.
- .12 Where thermometers, gauges, and similar instruments occur in insulated piping, and where access to heat transfer piping balancing valve ports and similar items are required, create a neat, properly sized hole in the insulation and provide a suitable grommet in the opening.

3.2 Additional Insulation Work Required

- .1 As part of the work of "Dentistry Clinic Renewal – MDR Implementation – Demolition and Abatement", University Project Number: P065-18-083, the University has retained an abatement contractor to remove asbestos insulation from mechanical services serving spaces within the Dentistry building.
- .2 Be responsible for re-insulating all mechanical services that are installed above spaces that are part of this contract including but not limited to:
 - .1 Room/Space 19 – Lecture Hall;
 - .2 Room/Space 113 – MDR.

- .3 Provision of all new insulation work shall be in accordance with the requirements of this section.
- .4 Refer to the documents provided for University Project No. P065-18-083 for additional information pertaining to your work.

3.3 Insulation for Horizontal Pipe at Hangers and Supports

- .1 At each hanger and support location for piping 50 mm (2") diameter and larger and scheduled to be insulated, except where roller hangers and/or supports are required, and unless otherwise specified, supply a factory fabricated section of phenolic foam pipe insulation with integral vapour barrier jacket and captive galvanized steel shield. Supply the insulation sections to the piping installers for installation as the pipe is erected.
- .2 For 100 mm (4") diameter and larger heating system piping where roller type hangers and supports are provided, a steel saddle will be tack welded to the pipe at each roller hanger or support location. Pack saddle voids with loose mineral wool insulation.

3.4 Pipe Insulation Requirements - Mineral Fibre

- .1 Insulate the following pipe inside the building and above ground with mineral fibre insulation of the thickness indicated:
 - .1 domestic cold water piping to and including 100 mm (4") dia. – 25 mm (1") thick;
 - .2 domestic cold water piping larger than 100 mm (4") dia. – 40 mm (1½") thick;
 - .3 domestic hot water piping, to and including 40 mm (1½") dia. – 25 mm (1") thick;
 - .4 domestic hot water piping, larger than 40 mm (1½") dia. – 40 mm (1½");
 - .5 tempered domestic water piping, supply and return, to and including 40 mm (1½") dia. – 25 mm (1") thick;
 - .6 tempered domestic water piping, supply and return, larger than 40 mm (1½") 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 hot water heating piping, supply and return, to 40 mm (1½") dia. – 40 mm (1½") thick;
 - .10 hot water heating piping, supply and return, 40 mm (1½") dia. and larger – 50 mm (2") thick;
 - .11 glycol solution heating or heat reclaim piping, supply and return, to 40 mm (1½") dia. – 40 mm (1½") thick;
 - .12 glycol solution heating or heat reclaim piping, supply and return, 40 mm (1½") dia. and larger – 50 mm (2") thick;

- .13 all piping as above located inside building in unheated areas and indicated to be traced with electric heating cable – minimum 50 mm (2") thick;
- .14 drum drip(s) in dry zone standpipe and/or sprinkler system piping – 50 mm (2") thick;
- .15 refrigerant suction piping (between compressor and evaporator coil) inside building – 25 mm (1") thick;
- .16 refrigerant hot gas piping (between compressor and condenser) inside building – 25 mm (1") thick;
- .17 refrigerant hot gas by-pass piping (between compressor discharge and evaporator coil) inside building – 25 mm (1") thick;
- .18 air compressor set fresh air intake piping – 25 mm (1") thick;
- .2 **Piping:** Ensure that the overlap flap of the sectional insulation jacket is secured tightly in place. Cover section to section butt joints with tape sealant.
- .3 **Fittings:** Insulate fittings with sectional pipe insulation mitred to fit tightly, and cover butt joints with tape sealant, or, alternatively, wrap fittings with blanket mineral fibre insulation to a thickness and insulating value equal to the sectional insulation, secure in place with adhesive and/or wire, and cover with PVC fitting covers.
- .4 **"Cold" Piping Unions, Valves, Strainers, Etc.:** Unless otherwise specified, insulate unions, valves, strainers, and similar piping system accessories in "cold" piping such as domestic water or chilled water piping with cut and tightly fitted segments of sectional pipe insulation with all joints covered with tape sealant, or, alternatively, wrap the piping union, valve, strainer, etc., with blanket mineral fibre and cover with PVC covers as for "Fittings" above.
- .5 **Flanges and Mechanical Couplings:** Terminate sectional insulation approximately 50 mm (2") from the flange or coupling on each side of the flange or coupling. Cover the flange or coupling with a minimum 50 mm (2") thickness of blanket mineral fibre insulation wide enough to butt tightly to the ends of the adjacent sectional insulation. Secure the blanket insulation in place and cover with a purpose made purpose made PVC coupling cover.
- .6 **Fire Protection Piping Drum Drips:** Drum drips in dry zone sprinkler and/or standpipe system piping will be traced with electric heating cable as part of the electrical work and are generally not shown on the drawing(s). Confirm the number and size of the drum drips required with the trade providing the piping and include for the insulation to suit. Note that wherever possible drum drips will be located in heated areas.
- .7 **Concealed Rough-In Piping at Plumbing Fixtures:** Take special care at concealed water rough-in piping at plumbing fixtures to ensure that the piping is properly insulated. If necessary due to space limitations, use 12 mm (½") thick sectional pipe insulation in lieu of 25 mm (1") thick insulation.
- .8 **Piping:** Generally, install as specified above for mineral fibre insulation.
- .9 **Fittings, Valve, Etc.:** Generally, install as specified above for mineral fibre insulation but cover with canvas, not PVC fitting covers.

3.5 Pipe Insulation Requirements – Flexible Foam Elastomeric (closed cell)

- .1 Install flexible elastomeric pipe insulation in strict accordance with the manufacturer's published instructions to suit the application, and using adhesive, joint sealants and finish to produce a water-tight installation. Insulate the following pipe with flexible elastomeric pipe insulation of the thickness indicated.

- .1 refrigerant suction and hot gas piping outside the building – 25 mm (1") thick.

3.6 Pipe Insulation Requirements – Fire Rated Insulation

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

3.7 Installation Of Weather-Proof Jacketed Insulation

- .1 Install sectional weather-proof jacketed pipe insulation in strict accordance with the manufacturer's instructions to produce a water-tight weatherproof installation. Insulate fittings with blanket type glass fibre insulation of a thickness and insulating value equal to the sectional insulation and secured in place with adhesive and wire. Jacket fittings with manufactured aluminium fitting covers sealed water-tight. Insulate the following pipe with weather-proof jacketed insulation:

- .1 Refrigerant suction and hot gas piping outside the building.

3.8 Installation Of Barrier Free Lavatory Insulation Kits

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

3.9 Equipment Insulation Requirements - Blanket Type Mineral Fibre

- .1 Insulate the following equipment with mineral fibre blanket type insulation of the thickness indicated:
 - .1 chilled water and/or domestic cold water pump casings – 40 mm (1½") thick;
 - .2 roof drain sumps where inside the building – 25 mm (1") thick.
- .2 Unless otherwise noted, wrap the equipment to a thickness and insulating value equal to an equivalent thickness of rigid sectional pipe insulation. Laminate the insulation in place with a full coverage of adhesive and secure with wire. Apply a jacket of the 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 the fibreglass blanket on radiant ceiling panels after testing is complete.

3.10 Equipment Insulation Requirements - Semi-Rigid Mineral Fibre

- .1 Insulate the following equipment with semi-rigid mineral fibre board insulation of the thickness indicated:
 - .1 Domestic water expansion tank – 40 mm (1½") thick.

- .2 Install the insulation as required to fit the shape and contour of the equipment. Secure the insulation in place with adhesive, and with aluminium straps on 450 mm (18") centres. Apply a 6 mm ($\frac{1}{4}$ ") thick skim coat of insulating cement, then, when the insulating cement has dried, apply a 6 mm ($\frac{1}{4}$ ") thick coat of cement trowelled smooth.
- .3 For "cold" equipment, prime the 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.
- .4 Provide removable and replaceable insulated metal covers for all equipment with removable heads to permit the heads to be removed and replaced without damaging the adjacent insulation work.

3.11 Ductwork Insulation Requirements - Mineral Fibre

- .1 Insulate the following ductwork systems inside the building and above ground with mineral fibre insulation of the thickness indicated:
 - .1 all 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 the first heating coil, or if both mixing plenums or sections and heating coil sections are not provided, and the fresh air is not tempered, then the fresh air ductwork system complete – minimum 40 mm ($1\frac{1}{2}$ ") 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 ($1\frac{1}{2}$ ") thick flexible blanket as required;
 - .3 supply air ductwork outward from fans, except for supply ductwork exposed in the area it serves – minimum 25 mm (1") thick rigid board or minimum 40 mm ($1\frac{1}{2}$ ") 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 ($1\frac{1}{2}$ ") thick flexible blanket as required;
 - .5 any other ductwork, casings, plenums or sections specified or detailed on the drawings to be insulated – thickness as specified.
- .2 Insulation for casings, plenums, and exposed rectangular ductwork is to be rigid board type. Insulation for round ductwork and concealed rectangular ductwork is to be blanket type.
- .3 **Exposed Rectangular Ducts and/or Casings:** Liberally apply adhesive to all surfaces of the duct and/or casing. Accurately and neatly press the insulation into the 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 all joints with 75 mm (3") wide tape sealant. Additional installation requirements are as follows:
 - .1 at trapeze hanger locations install insulation between the duct and the 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 the insulation is subject to accidental damage, and secure in place with tape sealant.

- .4 **Concealed Rectangular or Oval Ductwork:** Liberally apply adhesive to all surfaces of the duct and wrap the insulation around the 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 all joints with 75 mm (3") tape sealant. Additional installation requirements are as follows:
 - .1 at each trapeze type duct hanger provide a 100 mm (4") wide full length piece of rigid mineral fibre board insulation between the duct and the hanger.
- .5 **Exposed & Concealed Round or Oval Ductwork:** Accurately cut sections of insulation to fit tightly and completely around the duct. Liberally apply adhesive to all surfaces of the duct and wrap the insulation around the duct with a top butt joint and tight section to section butt joints. Seal all joints with tape sealant. At duct hanger locations install the insulation between the duct and hanger. At each hanger location for concealed ductwork where flexible blanket insulation is used, provide a 100 mm (4") wide full circumference strip of semi-rigid board type duct insulation between the duct and the hanger.
- .6 **Common Duct Insulation Requirements:** Insulation application requirements common to all types of rigid ductwork are as follows:
 - .1 at duct connection flanges insulate the flanges with neatly cut strips of the rigid insulation material secured with adhesive to side surfaces of the flange with a top strip to cover the exposed edges of the side strips, then butt the flat surface duct insulation up tight to the flange insulation, or, alternatively, increase the insulation thickness to the depth of the flange and cover the top of the flanges with tape sealant;
 - .2 the installation of fastener pins and washers is to be concurrent with the duct insulation application;
 - .3 cut insulation fastener pins almost flush to the 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 all vapour barrier damage by means of tape sealant.

3.12 Ductwork Insulation Requirements - Flexible Elastomeric

- .1 Insulate all exposed exterior ductwork (except fresh air intake ductwork) and associated plenums and/or casings outside the building with minimum 40 mm (1½") thick flexible elastomeric sheet insulation as required, applied in two minimum 20 mm (¾") thick layers with staggered tightly butted joints.
- .2 Install with adhesive in strict accordance with the manufacturer's published instructions to produce a weather-proof installation. Ensure that sheet metal work joints are sealed watertight prior to applying insulation.

3.13 Application of Insulating Coatings

- .1 Apply, in accordance with the manufacturer's instruction, insulating coatings to the following bare metal surfaces:

- .1 paint all 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 the pipe or equipment insulation, with "No Sweat-FX" anti-condensation coating;
- .2 paint all 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.

3.14 Insulation Finish Requirements

- .1 **Canvas:** Unless otherwise shown and/or specified, jacket all exposed mineral fibre insulation, and calcium silicate duct insulation work inside the building with canvas secured in place with a full 100% 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 **White PVC:** Jacket exposed pipe insulation work inside the 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 all joints to produce a neat water-tight installation. Provide slip-type expansion joints where required by manufacturer's instructions.
- .3 **Rigid Aluminum:** Install aluminum jacket material tightly in place with overlapped circumferential joints positioned to shed water and covered with butt straps supplied with the jacket. Provide aluminum jacket for the following insulation:
 - .1 Steam piping outside the building;
 - .2 Chilled water outside the building
 - .3 Refrigerant suction and hot gas piping outside the building;
- .4 **Protective Coating - Foamed Glass Insulation:** Apply two heavy coats of "PITTCOTE 404" coating with 24 hr. between coats to all foamed glass insulation exposed above grade.
- .5 **Protective Coating – Flexible Elastomeric Insulation:** Apply 2 coats (with 24 hr. between coats) of the specified coating to all insulation outside the 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.

1.2 Submittals

- .1 Submit documentation to confirm that reclaimed refrigerant has been properly removed and stored, recycled, or disposed of as applicable.

PART 2 - PRODUCTS

2.1 Not Applicable

PART 3 - EXECUTION

3.1 Disconnection and Removal of Existing Mechanical Work

- .1 Where indicated on the contract documents, disconnect and remove existing mechanical work, including hangers, supports, insulation, etc. Disconnect at the point of supply, remove obsolete connecting services and make the system safe. Cut back obsolete piping behind finishes and cap water-tight unless otherwise specified.
- .2 The scope and extent of the demolition or revision work is only generally indicated on the contract documents. Estimate the scope, extent and cost of the work at the site during the bidding period site visit(s). Claims for extra costs for demolition work not shown or specified but clearly visible or ascertainable at the site during bidding period site visits will not be allowed.
- .3 If any re-design is required due to discrepancies between the mechanical contract documents and site conditions, notify the Consultant who will issue a Site Instruction. If, in the opinion of the Consultant, discrepancies between the mechanical contract documents and actual site conditions are of a minor nature, the 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 the services in operation. Include for rerouting existing services concealed behind existing finishes and which become exposed during the renovation work, so as to be concealed behind new or existing finishes.
- .5 Unless otherwise specified, remove from the site and dispose of all existing materials which have been removed and are not to be relocated or reused. Refer to waste management and disposal requirements specified in the mechanical work Section entitled Basic Mechanical Materials and Methods.
- .6 Unless otherwise specified, remove from the site and dispose of all existing materials which have been removed and are not to be relocated or reused.

3.2 Hazardous Waste

- .1 If hazardous waste not listed in the Specification is found, notify the Owner and Consultant immediately and await directions.

3.3 Interruption to and Shut-Down of Mechanical Services And Systems

- .1 Co-ordinate all shut-down and interruption to existing mechanical systems with the Owner. Generally, shut-downs may be performed only between the hours of 6 pm to 6 am Monday to Friday.
- .2 Upon award of contract, submit a list of anticipated shut-down times and their maximum duration.
- .3 Prior to each shut-down or interruption, inform the Owner in writing seventy-two hours in advance of the proposed shut-down or interruption and obtain written approval to proceed. Do not shut-down or interrupt any system or service without such written approval.
- .4 Perform work associated with shut-downs and interruptions as continuous operations to minimize the shut-down time and to reinstate the systems as soon as possible, and, prior to any shut-down, ensure that all materials and labour required to complete the work for which the shut-down is required are available at the site.

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 Submittals

- .1 **Name and Qualifications of Testing and Balancing Agency:** Within thirty days of work commencing at the site, submit the name and qualifications of the proposed testing and balancing agency in accordance with requirements of the article entitled Quality Assurance below.
- .2 **Sample Test Forms:** Submit sample test forms, if other than those standard forms prepared by the Associated Air Balance Council (AABC) or National Environmental Balancing Bureau (NEBB) are proposed for use.
- .3 **Drawing Evaluation Report:** Submit a report by the Agency to indicate the Agency's evaluation of the mechanical drawings with respect to service routing and location or lack of balancing devices. Include the set of drawings used and marked-up by the Agency to prepare the report.
- .4 **Site Visit Reports:** Submit a report by the Agency after each site visit made by the Agency during the construction phase of this Project.
- .5 **Draft Report:** Submit a draft report, as specified in Part 3 of this Section.
- .6 **Final Report:** Submit a final report, as specified in Part 3 of this Section.
- .7 **Warranty:** Submit a testing and balancing warranty as specified in Part 3 of this Section.
- .8 **Post Construction Site Visit Reports:** Submit reports listing observations and results of post construction site visits as specified in Part 3 of this Section.

1.3 Definitions

- .1 The following are definitions of words used in this Section:
 - .1 "TAB" – means testing, adjusting and balancing to determine and confirm quantitative performance of equipment and systems and to regulate the specified fluid flow rate and air patterns at the terminal equipment, e.g., reduce fan speed, throttling, etc.;
 - .2 "hydronic systems" – includes heating water, chilled water, glycol-water solution, condenser water, and any similar system;
 - .3 "air systems" – includes all outside air, supply air, return air, exhaust air, and relief air systems;
 - .4 "flow rate tolerance" – means the allowable percentage variation, minus to plus, of actual flow rate values in the Contract Documents;

- .5 “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 the permanent record to be used as the basis for required future testing, adjusting and balancing;
- .6 “terminal” – means the point where the 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;
- .7 “main” – means the duct or pipe containing the system’s major or entire fluid flow;
- .8 “submain” – means the duct or pipe containing part of the systems’ capacity and serving two or more branch mains;
- .9 “branch main” – means duct or pipe servicing two or more terminals;
- .10 “branch” – means duct or pipe serving a single terminal.

1.4 Quality Assurance

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

1.5 Acceptable list of TAB firms:

- .1 Air & Water Precision Balancing;
- .2 Designtest & Balancing Co Ltd.;
- .3 Flowset Balancing Ltd.;
- .4 **Dymanic Flow Balancing.**

PART 2 - PRODUCTS

Not Applicable

PART 3 - EXECUTION

3.1 Scope of Work

- .1 Perform total mechanical systems testing, adjusting, and balancing. Requirements include measurement and establishment of the fluid quantities of the mechanical systems as required to meet design specifications and comfort conditions, and recording and reporting the results.
- .2 Mechanical systems to be tested, adjusted and balanced include:
 - .1 **Domestic Water Systems:** TAB of domestic water systems (all piping extended from the Municipal main) is to include:
 - .1 domestic hot water recirculation piping;
 - .2 tempered water piping flows.
 - .2 **Heating Systems:** TAB of heating systems is to include all piping and equipment fluid temperatures, pressure, flows and control, and if TAB is not done during the heating season, a follow-up site visit during the heating season will be required to confirm proper flows and temperatures, and any required system "fine tuning".
 - .3 **Cooling Systems:** TAB of cooling systems is also to include all piping and equipment fluid temperatures, flows and control, and if TAB is not done during the cooling season, a follow-up site visit during the cooling season will be required to confirm proper flows and temperatures, and any required system "fine tuning".
 - .4 **Existing Systems:** All of the existing systems revised as part of the mechanical work, are to be tested, adjusted and balanced as for new systems.

3.2 Testing, Adjusting and Balancing

- .1 **General Requirements:** Conform to the following requirements:
 - .1 as soon as possible after award of Contract, the 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 the results of the evaluation;
 - .2 the set of drawings examined by the Agency is to be returned with the 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 the mechanical work drawings and specification, the Agency is to visit the site at frequent, regular intervals during construction of the 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, the Agency is to report results of the site visit indicating the date and time of the 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:
 - .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 all 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 all applicable mechanical plant equipment and terminals, and temperature control diagrams and sequences;
- .8 the Agency is to walk each system from the system "head end" equipment to terminal units to determine variations of installation from design, and the system installation trades will accompany the Agency;
- .9 the Agency is to check all valves and dampers for correct and locked position, and temperature control systems for completeness of installation before starting equipment;
- .10 wherever possible, the Agency is to lock all balancing devices in place at the proper setting, and permanently mark settings on all devices;
- .11 for belt-driven equipment, the Agency is to report to the Commissioning Agent who in turn is to inform the Contractor and Consultant of any situation where sheaves have to be replaced to suit testing and balancing, and replacements are to be done by the Contractor at no cost;
- .12 the Agency is to leak test all ductwork as specified in Section 23 31 05 in accordance with requirements of SMACNA "HVAC Air Duct Leak Test Manual", coordinate work with the work of Section 23 31 05, provide detailed sketch(es) to Sheet Metal Contractor and Consultant identifying ductwork not in accordance with acceptable leakage values specified in Section 23 31 05 and 23 31 06, and retest corrected ductwork;
- .13 **noise:** the Agency is to balance all 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 the design conditions, the Agency is to immediately report the problem and submit data, including sound readings, to permit an accurate assessment of the noise problem to be made;
- .14 **stratification:** the Agency is to check all supply air handling system mixing plenums for stratification, and where the variation of mixed air temperature across coils is found to be in excess of plus or minus 5 percent of design requirements, the Agency is to report the problem and issue a detail sketch of plenum baffle(s) required to eliminate the stratification;

- .15 **tolerances:** the Agency is to perform testing, adjusting and balancing to within plus or minus 5% of design values, and make and record measurements which are within plus or minus 2% of actual values;
 - .16 **filters** for all air handling systems equipped with air filters, test and balance the systems with simulated 50% loaded (dirty) filters by providing a false pressure drop;
 - .17 **seasonal requirements:** test, adjust and balance air conditioning systems during the 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 **Preparation of Reports:** Prepare reports as indicated below.
- .1 **Draft Reports:** 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 the same manner specified for the final reports. Submit two complete sets of draft reports. Only one complete set of draft reports will be returned.
 - .2 **Final Report:** 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 the Project Documents.
 - .3 **Report Format:** 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 in reinforced, vinyl, three-ring binders. Provide binding edge labels with the project identification and a title descriptive of the contents. Divide the contents of the binder into the divisions listed below, separated by divider tabs:
 - .1 General Information and Summary;
 - .2 Air Systems;
 - .3 Hydronic Systems;
 - .4 Temperature Control Systems;
 - .5 Special Systems.

- .4 **Report Contents:** The Agency is to provide the following minimum information, forms and data:
 - .1 inside cover sheet to identify the Agency, the Contractor, and Project, including addresses, and contact names and telephone numbers and a listing of the instrumentation used for the procedures along with the proof of calibration;
 - .2 the remainder of the report is to contain the appropriate forms containing as a minimum, the information indicated on the standard AABC or NEBB report forms prepared for each respective item and system;
 - .3 the 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 all equipment, terminals, and accessories;
 - .4 the Agency is to include report sheets indicating building comfort test readings for all rooms.
- .3 **Verification of Reports:** After the final testing and balancing report has been submitted, the Agency is to visit the site with the Contractor and Consultant to spot check results indicated on the balancing report. The Agency is to supply all labour, ladders, and instruments to complete spot checks. Note that if results of spot checks do not, on a consistent basis, agree with the final report, the spot check procedures will stop and the Agency is to then rebalance the systems involved, resubmit the final report, and again perform spot checks with the Contractor and Consultant. A maximum of 30% of all terminal equipment will be checked.
- .4 **Certification and Warranty:** When the final report has been accepted, the Contractor is to submit to the Owner, in the name of the Owner, a certificate equal to the AABC National Guaranty Certification or a NEBB Quality Assurance Program Bond, and in addition, the Contractor is to submit a written extended warranty from the Agency covering one full heating season and one full cooling season, during which time any balancing problems which occur, with the exception of minor revision work done during scheduled site visits, will, at no cost, be investigated by the Agency and reported on to the Owner, and if it is determined that the problems are a result of improper testing, adjusting and balancing, they are to be immediately corrected without additional cost to the Owner.
- .5 **Post Balancing Site Visits:** After acceptance of the final report, the Agency is to perform post testing and balancing site visits in accordance with the following requirements:
 - .1 post testing and balancing site visits are to be made:
 - .1 once during the first month of building operation;
 - .2 once during the third month of building operation;
 - .3 once between the fourth and tenth months in a season opposite to the first and third month visit.
 - .2 during each return visit and accompanied by the Owner's representative, the Agency is to spot rebalance terminal units as required to suit building occupants

and eliminate complaints;

- .3 the Agency is to schedule each visit with the Contractor and the Owner, and inform the Consultant;
- .4 after each follow-up site visit, the Agency is to issue to the Contractor and Consultant a report indicating any corrective work performed during the visit, all abnormal conditions and complaints encountered, and recommended corrective action.

.6 Balancing of Existing Systems

- .1 As soon as possible after award of Contract, the Agency balance supply fan S-16 and return fan R-16 serving the existing spaces in the facility along with all of the supply and return outlets within the existing spaces. Refer to the mechanical as-built drawings provided by the University of Toronto as part of the tender documents for information regarding the air volumes the spaces are to be balanced to.
- .2 In addition to balancing the air handling and air distribution systems, be responsible for re-balancing the cooling coil, heating coil(s) and circulating pumps serving the heating and cooling systems connected to supply fan S-16. Consultant will provide details regarding the flows to be used for balancing purposes after award of Contract.
- .3 All balancing work is to take place after hours between 6 pm and 6 am Monday to Friday.

END OF SECTION

1 GENERAL

1.1 Scope

- .1 Provide commissioning of mechanical systems provided under Division 20, 21, 22, 23 and 25.
- .2 Mechanical system installation, start-up, testing, balancing, preparation of O&M manuals and operator training are the responsibility of the Division 20 Contractors, with the coordination of the commissioning process the responsibility of the General Contractor/ Construction Manager.
- .3 Include all labor and material as required to participate in the commissioning process, as outlined in this section, for equipment installed under Division 20.

1.2 Related work

- .1 Commission mechanical systems in conjunction with:
 - .1 Section 01 91 15, General Commissioning Requirements
 - .2 Section 20 08 01, Start-up and Performance Testing
 - .3 Section 20 05 50, Testing, Adjusting and Balancing
 - .4 Section 26 08 15, Electrical Commissioning

1.3 Reference Standards

- .1 Comply with the latest edition of the following:
 - .1 ASHRAE Guideline 1-1996 The HVAC Commissioning Process, as amended herein.
 - .2 University of Toronto Commissioning Process: Overall Building Commissioning Rev 3
 - .3 University of Toronto – Building Automation Systems Design Standards and Guidelines Rev 7

1.4 Commissioning Process

- .1 The Commissioning process develops, coordinates, and documents the following:
 - .1 Equipment start-up
 - .2 Control system calibration
 - .3 Testing and balancing
 - .4 Verification and Performance Testing
 - .5 Operation documentation
 - .6 Operator training

- .2 The Commissioning Program is divided into the following parts:
 - .1 Part 1: Pre-Start and Start-Up testing
 - .2 Part 2: Installation Verification testing
 - .3 Part 3: Functional Performance Testing
 - .4 Part 4: Systems Operating & Maintenance Manuals
 - .5 Part 5: Operator Training

1.5 Work Included

- .1 Commissioning work of Division 20, 21, 22, 23, and 25 include, but are not limited to:
 - .1 Participation in regular construction meetings as well as separate Commissioning Meetings during the construction period associated with the scheduling, coordination, and implementation of the various commissioning activities within the overall construction program.
 - .2 Testing and start-up of equipment.
 - .3 Testing, adjusting and balancing of hydronic and air systems.
 - .4 Cooperation with the Commissioning Authority in developing and implementation of the commissioning plan.
 - .5 Providing qualified personnel for participation in implementing commissioning test procedures, including seasonal testing required after the initial testing.
 - .6 Providing equipment, materials, and labor as necessary to correct construction and/or equipment deficiencies found during the commissioning process.
 - .7 Providing operation and maintenance manuals, and as-built drawings to the Commissioning Authority for verification.
 - .8 Providing training and demonstrations for the systems specified in this Division.
 - .9 Assist in performing warranty review of Mechanical and Electrical systems.
- .2 Conduct complete and thorough evaluation and documentation of the operation and performance of all components, systems, and sub-systems, including the following equipment and systems:
 - .1 Heating and cooling systems
 - .2 Air handling units
 - .3 Heat recovery systems
 - .4 VAVs
 - .5 AC units
 - .6 Fans
 - .7 Building Automation System (BAS)
 - .8 EMRS integration
 - .9 Domestic cold and hot water system

- .10 Lab gas - compressed air and vacuum systems
- .11 Fire protection
- .3 Commission equipment which has been supplied by the mechanical contractors, as well as pre-tendered, pre-purchased, or pre-ordered by the Owner or their Agent, and the value of which has been assigned to the Mechanical Contractor or their sub-trades and is included in the value of the Work.
- .4 Commission services to equipment, but not the equipment itself, where the supply of the equipment does not form part of the mechanical Work.
- .5 Provide the following commissioning documentation:
 - .1 recording completed Pre-start and Start-up procedures test results,
 - .2 recording completed Installation Verification and Performance Validation test results,
 - .3 As-built records.
 - .4 Operation and maintenance manuals
- .6 The final commissioning report will be prepared by the Commissioning Authority.

1.6 Definitions

- .1 *Major deficiency* – an item which if not corrected renders the equipment or system unsuitable or un-safe for use by the Owner. Major deficiencies must be corrected as a condition for achieving Substantial Performance.
- .2 *Minor deficiency* – an item which does not impact on the operation of the equipment or system and will allow the Owner to use the system safely. Minor deficiencies may be corrected before or after Substantial Performance, but will not prevent certification of Substantial Performance of the Work.

1.7 Commissioning Schedule

- .1 Provide a detailed commissioning schedule for consolidation into the main construction schedule.
- .2 Include:
 - .1 equipment and systems start-up predecessors
 - .2 time periods for pre-start and start up testing, verification and validation testing for each equipment and system.

1.8 Documentation Deliverables

- .1 Identify documents including test documents, binder covers, etc. using equipment ID numbers provided on equipment schedules.

- .2 Scan original signed test reports, including verification and performance test reports, manufacturers service reports, etc. in Adobe Acrobat *.pdf version 8 format. For original document chapters, provide Adobe chapter referencing.
- .3 Submit three (3) copies of each completed and accepted Verification and Functional Performance Test reports, both preliminary and final issues.
- .4 Collate final, accepted and signed test results in separate binders as follows:
 - .1 Fire Protection
 - .2 Plumbing and Drainage
 - .3 HVAC Systems
 - .4 Building Management Systems
- .5 Provide three (3) copies of commissioning documentation.

1.9 Substantial Performance

- .1 Substantial Performance
- .2 Application for Substantial Performance of the Work is precedent on the Work being ready for Owner's use which includes completion of the following commissioning elements:
 - .1 Start-Up and testing, including TAB reports,
 - .2 Commissioning Verification testing including submission of completed records,
 - .3 Commissioning Performance Validation testing including submission of completed records, except for alternate season tests,
 - .4 Commissioning Controls Validation testing,
 - .5 Training of Owner's operations personnel,
 - .6 As-built documentation issued for Consultant's review,
 - .7 Operations and Maintenance manuals which have been reviewed by the Consultant and accepted by the Owner.

1.10 Test Equipment

- .1 Furnish tools and equipment required during the commissioning process.
- .2 Utilities (water, gas, fuel oil, electrical power) are provided by the Owner
- .3 Provide any proprietary test equipment and software required by equipment manufacturer for programming and / or start-up, whether specified or not.
- .4 Manufacturer provides test equipment, demonstrate its use, and assists in the commissioning process as needed.

- .5 Turn-over proprietary test equipment to the Owner upon completion of the commissioning process, where such requirement is specified in the relevant equipment specification sections.

2 ORGANIZATION

2.1 General

- .1 Complete all phases of work so that the systems can be started, tested, balanced, and owner's acceptance procedures (see article 3.4.11) be undertaken in a timely manner such that only one acceptance test is conducted at any one time.
- .2 Participate and assist in the development of the Commissioning Plan and schedule by the General Contractor, by providing necessary information pertaining to the equipment and installation. Provide commissioning schedule information to be incorporated into the overall Construction Plan schedule.
- .3 Acceptance procedures may begin prior to completion of a system and/or sub-system. Start of acceptance procedures before system completion does not relieve the Contractor from completing those systems in accordance with the commissioning and construction schedule.

2.2 Participants

- .1 Commissioning Team consists of multiple parties with separate responsibilities.
- .2 Owner:
 - .1 establishes acceptance criteria,
 - .2 provides operations staff to receive training, and to witness any or all tests at their discretion,
 - .3 final acceptance of commissioning results.
- .3 Design Consultant:
 - .1 responsible for the construction review activities in accordance with local building code requirements,
 - .2 may participate in development and / or review of commissioning procedures,
 - .3 reviews commissioning test results,
- .4 Commissioning Authority:
 - .1 develops commissioning plan and procedures,
 - .2 coordinates Owner's commissioning team members who witnesses tests,
 - .3 selectively witnesses commissioning tests on an audit basis to confirm compliance by the Contractor to the Commissioning Plan,
 - .4 reviews commissioning test results and makes recommendations to the Owner for acceptance.

- .5 General Contractor / Construction Manager:
 - .1 coordinates and manages commissioning activities,
 - .2 develops and integrates commissioning activities into the construction schedule,
 - .3 ensures commissioning procedures are completed and documented, and commissioning records including any required attachments are submitted.
- .6 Mechanical trades Contractors:
 - .1 Provide the services of qualified technician(s) who are familiar with the construction and operation of the system, to start-up and debug equipment and systems within the Division 20, 21, 22, 23, and 25 scope of Work. Include for labour, materials, and subsistence costs for these same technicians to assist the Commissioning Authority in completing the commissioning program.
 - .2 Provide access to the contract plans, shop drawings, and equipment cut sheets of all installed equipment.
 - .3 Ensure the qualified technician(s) are available and present during commissioning testing to complete the tests, make adjustments and to assist in problem resolutions.
 - .4 Should any equipment or system experience performance problems and/or reconstruction or replacement of components is required, include for additional technician time for subsequent retesting of systems until required system performance is achieved.
 - .5 The Commissioning Authority reserves the right to approve proposed technicians with regard to the technical skill level required for each type of equipment and/or system, and a willingness by the individual(s) to work within the Commissioning Group.
- .7 Controls Contractor, in addition to the requirements described above:
 - .1 Provide test reports using own documentation formats, for wiring tests, loop testing, loop tuning, and sequence functional tests.
 - .2 Provide details of the control system, schematics, and a narrative description of control sequences of operation.
- .8 Electrical Contractor:
 - .1 provide a foreman electrician familiar with the electrical interlocks, interfaces with emergency power supply, and interfaces with alarm and life-safety systems. Provide access to the contract plans, and all as-built schematics of sub-systems, interfaces and interlocks.
- .9 Equipment suppliers:
 - .1 provide the services of manufacturers' service personnel to provide assistance with pre-start and initial start-up of the equipment, as required.

3 EXECUTION

3.1 Commissioning Meetings

Participate in periodic commissioning team meetings, and trade commissioning meetings

.2 Pre-construction:

- .1 participate in a pre-construction meeting of commissioning team members, to familiarize parties with the commissioning process, and to ensure that the responsibilities of each party are clearly understood.

.3 Construction and Post-Construction:

- .1 participate in commissioning meetings as scheduled by the General Contractor.
- .2 participate in trade commissioning meetings as required, in addition to the regular commissioning team meetings,
- .3 identify to the commissioning group problems relating to the commissioning schedule, identification of start-up issues, etc., and participate in the resolution of these problems.

3.2 Commissioning Procedures

.1 Startup Plan

- .1 The CxA will develop the prefunctional checklists and procedures.
- .2 The CxA transmits them to the Contractor who designates which trade or installer is responsible to fill out each line item on the Prefunctional Checklist from the CxA.
- .3 The contractor shall develop a Startup Plan which includes obtaining manufacturer installation, start-up and checkout data, and the completion of the Prefunctional Checklists.
- .4 For systems that may not have adequate manufacturer start-up and checkout procedures, particularly for components being integrated with other equipment, the Contractor should provide the added necessary detail and documenting format to the CxA for review and approval prior to execution.
- .5 The Contractor transmits the full Start-up Plan to the CxA for review and approval.
- .6 The CxA reviews and approves the procedures and the format for documenting.

.2 The Owner's designated Commissioning Authority provides the commissioning procedures (checklists, etc.) for use by the contractor.

.3 Execution of Checklists and Startup:

- .1 The Contractor shall notify the CxA four weeks prior to startup. The startup and initial review are directed and executed by the Contractor.
- .2 To document the process of startup and checkout, the site technician performing the line item task initials and dates each paragraph of procedures in the "Startup

Plan” and checks off items on the prefunctional and manufacturer field checkout sheets, as they are completed. Only individuals having direct knowledge of a line item being completed shall check or initial the forms.

- .3 The contractors and vendors execute the checklists and tests and submit a fully completed, signed and dated start-up and prefunctional tests and checklists to the CxA. The CxA will review and verify the prefunctional checklists upon completion. The checklists (which all contain more than one trade’s responsibility), will be passed around to the respective trades to fill out.
- .4 Deficiencies and Non-Conformance
 - .1 The Contractor clearly list any outstanding items of the initial start-up and prefunctional procedures that were not completed successfully at the bottom of the procedures form or on an attached sheet.
 - .2 The procedures form and deficiencies are provided to the CxA within two days of test completion.
 - .3 The CxA works with the Contractor and vendors to address deficiencies and/or uncompleted items necessary to meet Contract requirements.
 - .4 The installing Contractor or vendors correct all areas that are deficient or incomplete according to the checklists and tests, then re-performs the start-up and submits deficiency-free start-up reports to the CxA for review.
 - .5 The CxA approves the startup and initial checkout of each system.
- .5 Functional Performance Testing
 - .1 The CxA will provide commissioning functional performance test forms for use and execution by the contractor.
 - .2 The performance testing shall demonstrate that each system is operating according to the documented design intent and contract documents.
 - (a) Performance testing shall individual individual equipment tests and integrated systems test to verify interaction between equipment.
 - (b) Performance testing shall be conducted for all normal operation, alarm and emergency conditions and redundancies.
 - .3 The contractor/subcontractor shall notify the CxA two weeks prior to scheduling functional performance tests. The following documents must be submitted to the CxA prior to scheduling of functional performance tests
 - (a) Manufacturer startup reports
 - (b) Completed pre-functional checklists
 - (c) Testing, Adjusting and Balancing Reports
 - (d) Duct and pipe pressure test reports, if applicable
 - .4 The CxA oversees witnesses and documents the functional testing of all equipment and systems according to the Specifications and the Cx Plan.
 - .5 The Contractor executes the tests as documented.
- .6 Deficiencies and Retesting:

- .1 The CxA documents the results of the test.
 - (a) Any **major** deficiencies that are identified during testing may result in a halt and cancellation of further related component, equipment or system testing at the discretion of the CxA.
 - (b) Correction of **major** deficiencies must be completed and documented with an updated prefunctional and start-up checklist that is witnessed and signed by the Contractor prior to scheduling a functional re-test of the component, equipment or system with the CxA.
 - (c) Corrections of **minor** deficiencies identified are made during the tests at the discretion of the CxA.
 - (d) Where deemed either unnecessary or impossible to correct minor deficiencies during the functional tests, the Contractor are to perform the corrective work and provide evidence
- .2 The CxA records the results of the test on the procedure or test form.
 - (a) Deficiencies or non-conformance issues are noted and reported by the CxA.
 - (b) Contractor corrects deficiencies and notifies the the CxA.
 - (c) Contractor retests deficient items in the presence of the CxA to confirm resolution of deficiencies.
- .3 The CxA recommends acceptance of each test once functional performance is demonstrated without any deficiencies.

3.3 Roles and Responsibilities:

- .1 Refer to the project Commissioning Plan (Schedule A of Section 01 91 15) for commissioning roles and responsibilities.

3.4 Operating checks

- .1 The Commissioning Authority witnesses selected equipment and system tests on an audit basis.
- .2 Set the system equipment into operating mode to be tested including but not limited to:
 - .1 Normal shut-down
 - .2 Normal auto position
 - .3 Normal manual position
 - .4 Unoccupied cycle
 - .5 Emergency power operation, including transition states.
 - .6 Alarm conditions
- .3 Inspect and verify the position of each device and interlock identified on the checklist.
- .4 Repeat the above tests for each operating cycle that applies to the system being tested.

- .5 Check the operating condition of the following elements during all modes of operation of the system:
 - .1 Safety interlocks
 - .2 Alarms
 - .3 Life safety systems
- .6 For failed test items, provide appropriate comments to the checklist data sheet and classify whether it is a “Major” or “Minor” deficiency.
 - .1 The Consultant retains the right to make the final decision regarding classifications of deficiencies.
- .7 Verify the operational control of the systems through the Building Management System as follows:
 - .1 TAB airflow rates and calibrate terminal boxes in all modes of operation
 - .2 Equipment operation in both heating and cooling modes.
 - .3 Minimum outdoor air intake positions, air-side economizer cycles, and multi-set outdoor air damper positions as required for each operating sequence and mode.
 - .4 Room temperature setpoints.
- .8 Verify the proper responses of instrumentation and control devices (actuators) as follows:
 - .1 For each controller or sensor, record the indicated monitoring and control system reading, and the test instrument reading.
 - .2 If the initial test indicates that the test reading is outside of the control range of the installed device, check the calibration of the installed device and adjust as required. Re-test the deficient device and record the results on the checklist data sheets.
- .9 The Commissioning Authority witnesses the field verification of the final TAB report as follows:
 - .1 Select, at random, 10% of the report data for verification.
 - .2 The TAB contractor will be provided advance notice of the date of retesting, but not the equipment to be tested.
 - .3 The TAB contractor uses the same equipment and instruments used for collecting the original data.
- .10 Test failure is defined as:
 - .1 For all readings other than sound, a deviation of more than 10 percent from the TAB report results.
 - .2 A failure rate greater than 10% of the selected items (1% of all TAB test results) will result in rejection of the final TAB report.
- .11 Acceptance

- .1 The final reports will be reviewed by the Commissioning Authority and the Consultant, to determine if verification is complete and the operating systems are functioning in accordance with the contract documents.
- .2 The Commissioning Authority, in conjunction with the Consultant, reviews and makes final classification of all noted deficiencies. Correct deficiencies classified as "Major" before acceptance of the Verification stage.
- .3 The Owner will make the final acceptance of test results.

3.5 Problem Resolution

- .1 In the event that additional work is required to either correct systems, misapplied equipment, and/or deficient performance under varying load conditions, assist the Owner and Commissioning Authority in developing an acceptable resolution to the problem, including the resources of equipment suppliers.
- .2 The Owner has final approval over any additional work required to achieve the required level of performance.
- .3 Complete corrective work in a timely fashion to permit the completion of the commissioning process.

3.6 Acceptance

- .1 Any identified deficiencies will be reviewed by the Consultant in conjunction with the General Contractor/Construction Manager to determine if correction of the deficiency is as a result of a defect in the equipment or installation.
- .2 If it is determined the performance deficiency is as a result of a defect in the equipment or its installation, rectify the deficiency and repeat the performance test until the required performance levels are achieved.
- .3 If it is determined the equipment or system has been constructed in accordance with the contract documents, the Owner will decide whether to accept the performance as is, or, direct the installation contractor to make changes to the system as required to obtain performance levels which meet the design intent, and retest the system.

3.7 Seasonal Commissioning

- .1 Commence initial performance validation testing commissioning at the completion of the installation and verification testing phase. Conduct performance testing, which is weather dependent, as applicable to current seasonal conditions. Complete performance testing on non-weather dependent systems in accordance with the agreed commissioning plan schedule.
- .2 For out-of-season system performance testing, conduct initial performance tests to demonstrate off-peak load performance. Schedule peak load performance testing over the succeeding nine (9) months to ensure all equipment is tested at peak load prior to the expiry of the warranty period.

- .3 Test heating equipment/systems during winter design extremes.
- .4 Test cooling systems during summer design extremes with a fully occupied building.
- .5 Alternatively, provide temporary equipment (load banks, etc.) to simulate full load conditions. Submit proposed methodology for review by the Commissioning Authority and Consultant.

3.8 Additional Commissioning

- .1 Additional commissioning activities may be required after completion of system performance testing. Include in the tender cost a reasonable reserve to complete this work, including assistance from manufacturers' service technicians.

3.9 EMRS Integration

- .1 Refer to Schedule A for EMRS integration commissioning process and requirements.

3.10 Systems Operating Manuals

- .1 Provide Operating and Maintenance Manuals in accordance with the requirements of section 20 05 05.
- .2 The Systems Operating Manuals (SOM) are in addition to the Operating and Maintenance Manuals (OMM) required under Section 20 05 05.
 - .1 Provided by Commissioning Authority and/or Consultant.

3.11 Training

- .1 Equipment Training:
 - .1 Provide equipment training in accordance with Section 20 01 01. The manufacturer's representative training will emphasize operating instructions and preventative maintenance.
 - .2 Refer to Schedule A for BAS and EMRS training requirements.

END OF SECTION

4 SCHEDULE A – EMRS INTEGRATION COMMISSIONING PROCESS

4.1 EMRS Integration Commissioning Process

.1 Refer to attached document.

3.20.3 STANDARDS

3.20.3.1 The following standards shall be referenced in conjunction with this document.

3.20.3.1.1 Left <blank>

3.20.3.1.2 University of Toronto –Commissioning Process, Overall Building Commissioning:

<http://www.fs.utoronto.ca/wp-content/uploads/standards/commissioning/BuildingCommissioningProcess.pdf>

3.20.3.2 Comply with rules and regulations of codes and ordinances of local, provincial, and federal authorities, such codes and ordinances, when more restrictive, take precedence over the Contract Documents.

3.20.3.3 The Commissioning Process Roles and Responsibilities Matrix is provided under the Section 3.24 of this document.

3.20.4 PROCEDURE

3.20.4.1 General

3.20.4.1.1 The process has been described in stages in which required deliverables and responsibilities throughout the project development and implementation are defined. To ensure a smooth transition through the sequential stages through the project it is necessary that each stage's deliverables be submitted and accepted prior to entering the next stage.

3.20.4.1.2 The Cx Authority will be responsible to coordinate with all stakeholders to develop the Cx schedule that will incorporate these milestones and establish timelines as agreed by all stakeholders.

3.20.4.2 Design /Pre Tender Stage

3.20.4.2.1 The Basis of Design will be a document provided by the Design Engineer to the UOT Project Team for review. Refer to the Overall Building Commissioning Process Standard.

3.20.4.2.2 F&S Project Team will provide the Cx Team with estimates of time and cost to execute the integration of the BAS systems to the EMRS. The estimate is intended to provide the Cx team with approximate timelines required for F&S IT to complete various tasks.

3.20.4.3 Construction Stage

3.20.4.3.1 This stage in the process shall be completed prior to the occupancy or the mechanical building systems handover, whichever comes first.

- 3.20.4.3.2 The BAS contractor will provide the Shop drawing documentation to the Design Engineer for review. The Shop drawings must comply with section 1.11 of the UOT Building Automation Design standards.
- 3.20.4.3.3 Shop drawings reviewed by both Design engineer and Cx authority shall be submitted to F&S Project team for review and commencement of EMRS graphics. Only shop drawings marked as "Reviewed as noted" or "Approved" shall be submitted to the F&S project team. F&S Project team will return their comments for Design Engineer review/comments and incorporation in the final review of the Shop Drawings returned to the Project Consultant. The project shall allow in the schedule enough time for this review cycle to occur.
 - 3.20.4.3.3.1 The CxA shall review the documents from the commission ability standpoint. In their review, they should clearly state that the shop drawings have all required information for commissioning of the BAS system including testing all sequences of operation.
 - 3.20.4.3.3.2 The CxA shall submit their comments in editable document.
 - 3.20.4.3.3.3 The Design Engineer shall provide responses to each of the CxA comments in the editable document. This document shall be provided to F&S Project team with reviewed shop drawings for their record.
- 3.20.4.3.4 Submit the Approved/Reviewed as noted status BAS shop drawing to F&S Project team for review and commencing generation of EMRS graphics.
- 3.20.4.3.5 The Cx Authority will provide Functional Performance test scripts /BAS system Acceptance procedures to the Cx Team for review through an updated Cx Plan.
- 3.20.4.3.6 Acceptance procedure
 - 3.20.4.3.6.1 The Cx Authority shall complete:
 - 3.20.4.3.6.1.1 All functional performance tests as per Cx Plan and submits any discrepancies or issues noted through an issues log supported with concern, corrective measures, and responsibilities. Submit the issues log to the F&S Project team.
 - 3.20.4.3.6.1.2 Ensure that all field devices, including sensors, final control elements installed as per approved control schematics. Any discrepancies should be marked up and submitted as part of the Field Cx documentation.
 - 3.20.4.3.6.1.3 Ensure all Controllers, B-BC, B-ASC, B-AAC installed, powered up and commissioned as per the approved BAS shop drawing. Any discrepancies

- should be marked up and submitted as part of the Field Cx documentation.
- 3.20.4.3.6.1.4 Ensure all required physical networking are in compliance to Section 3.21 of the UOT Building Automation Design standards. Review and verify all Networking cable checklists and Fluke test reports submitted by the contractor. Any discrepancies should be marked up and submitted as part of the Field Cx documentation.
- 3.20.4.3.6.1.5 Ensure all graphical representations of systems are provided on the temporary vendor specific standalone BAS Workstation with the contractor's temporary installed Graphical User Interface in the building. Provisions of all required alarms, trends, monitoring and control points (physical & virtual) must be provided and verified by the CxA on the Graphical user interface (GUI) provided by the BAS contractor. Screenshots of the GUI pages should be included as a part of the Field Cx Documentation to aid in the development of EMRS graphics
- 3.20.4.3.6.1.6 Ensure that the alarms notifications for the predefined and approved critical control objects/points are being sent to the predefined list of the alarm recipients from the BAS workstation. The BAS vendor must supply its own dedicated temporary communication gateway and/or a modem device for the internet connectivity along with the SMTP service that is properly and securely configured and functional.
- 3.20.4.3.6.1.7 Ensure that all the Bacnet Analog Inputs and Outputs have properly configured Change of Value properties as defined in the Section 2.3.2.24 of this document.
- 3.20.4.3.6.1.8 Ensure all systems functional test forms after completion must be submitted as part of the Field Cx documentation.
- 3.20.4.3.6.1.9 Ensure that the EMRS Bacnet Compliance Test Readiness form is submitted based on the following template:

EMRS Bacnet Compliance Test Readiness Form

BAS Controls Contractor:

- ☐ Johnson Controls (JCI)
- ☐ Siemens (SBT)
- ☐ Honeywell (HBS)

BAS Controls Contractor Team,

We are in the preparation phase for the EMRS Bacnet Compliance Testing.

Below is the list of project(s) and the most current submittal of the mandatory documentation.

List of project(s):

<insert UofT Project Identification> ex. *P001-19-123 Main Building BAS Retrofit*)

As-Built Drawings – Network Architecture:

To be provided for all projects by BAS Controls Contractor. All drawings should have some references to the project numbers for the effective identification. The final markup drawings that reflects the completed state of the project are also acceptable.

The network architecture drawing is sufficient to show the B-BC and ASC/AAC riser for each B-BC. For the ASC/AAC architecture, the device count and traditional ASC/AAC schedule is sufficient, if exists.

EMRS Bacnet Implementation Metafile:

<insert the reference to the EMRS Bacnet Implementation Metafile> , ex. *P001-19-123 Main Building BAS Retrofit EMRS_BACNET_Implementation_Requirements_v3.0_05SEP2018.xlsx* (attached)

Wiring Installation Qualification Document:

<insert the reference to the Wiring Installation Qualification document based on the template listed here:

https://www.fs.utoronto.ca/wp-content/uploads/standards/bas/Wiring_Installation_Qualification_Form.docx

IMPORTANT NOTE

The attached documents must be reviewed by BAS Controls Contractor team as the documents will be used for the EMRS Bacnet Compliance Testing. Since all the information was shared, it is expected that the accuracy of the documentation will match the current on site installation. It is the responsibility of the BAS Controls Contractor to provide the proper information.

Any discrepancy between the documentation and the actual status during the compliance test will be flagged as FAILED.

ACTIONS REQUIRED:

1. BAS Controls Contractor to provide the as-built drawings or the final markup drawings that reflects the completed state of the projects. The network architecture drawings is sufficient to show the B-BC and AAC/ASC device count and the .
2. BAS Controls Contractor to provide the final confirmation that the projects are Network Ready and EMRS Ready.
 - a. Network Ready – YES --- NO
 - i. IP device can be pinged from the properly labeled patch panel based on the document: < Wiring Installation Qualification Document >
 - b. EMRS Ready – YES --- NO
 - i. B-BC and ASC/AAC are configured with the Bacnet Instance numbers and Bacnet Object names based on the document: < EMRS Bacnet Implementation Metafile >
 - ii. B-BC has properly defined Alarm Notification Classes based on the UofT BAS Standard
 - iii. B-BC and ASC/AAC have properly configured Bacnet Change of Value properties for all Analog Inputs and Analog Outputs
3. BAS Controls Contractor to provide specific report “EMRS Bacnet Compliance Test Readiness Form.docx” based on the template listed here:
[https://www.fs.utoronto.ca/wp-content/uploads/standards/bas/EMRS BACnet Compliance Test Readiness Form.docx](https://www.fs.utoronto.ca/wp-content/uploads/standards/bas/EMRS_BACnet_Compliance_Test_Readiness_Form.docx)
4. BAS Controls Contractor to provide specific report “Project Points List EMRS Submittal Form.xlsx” based on the template listed here:
[https://www.fs.utoronto.ca/wp-content/uploads/standards/bas/Project Points List EMRS Submittal Form.xlsx](https://www.fs.utoronto.ca/wp-content/uploads/standards/bas/Project_Points_List_EMRS_Submittal_Form.xlsx)
5. UofT F&S IT : On site EMRS Compliance Testing (Total of # B-BC controller) – expected completion: up to 5 business days following EMRS Ready report
6. UofT F&S IT : Final Report (pending on the test results) – expected completion: up to 5 business days following EMRS Ready report
7. UofT F&S IT : EMRS Integration (alarms, history trends) - expected completion: up to 5 business days following the Final Report
8. UofT F&S IT : EMRS Integration GUI (pending the final commissioning report) - expected completion: up to 6 weeks following the EMRS Integration

- 3.20.4.3.6.1.10 Verification of "As Built" versus "Detailed Design Requirement" form is submitted based on the following template:
- 3.20.4.3.6.1.10.1 Table identifying "Detailed Design Requirement" and corresponding "As Built" found in the field with sign off by the Commissioning Authority.
 - 3.20.4.3.6.1.10.2 Calibration certificate of end devices requiring calibration that identifies the device
 - 3.20.4.3.6.1.10.3 Calibration Tolerance limits (CTL) and the comparison of the CTL to the Process Calibration Tolerance Limits (PCTL) tabulated and signed off by the Commissioning Authority.
 - 3.20.4.3.6.1.10.4 Documentation of wiring used and the documented 100% verification of individual connections between the End Devices to the BAS Controller identifying individual IP Addresses and BACnet Instance Numbers for existence and correctness, tabulated and individually signed off by the Contractor
 - 3.20.4.3.6.1.10.5 Documentation of the connections between the BAS Controller and the BAS Patch Panel identifying the individual End Device, BAS Controller and BAS Patch Panel connection location, tabulated and individually signed off by the Contractor.
 - 3.20.4.3.6.1.10.6 Documentation of the individual connections between the BAS Patch Panel and the Network Switch tabulating all connections identifying individual BAS Patch Panel connection ports and F&S Network Switch connection ports, signed off by the University of Toronto (Central IT).
 - 3.20.4.3.6.1.10.7 Documentation of loop test of 100% connections from F&S Network Switch to End Device, tabulated to document integrity of signal and demonstrated Range of End Device process control capabilities, signed off by University of Toronto (IT), Contractor and Commissioning Authority.
 - 3.20.4.3.6.1.10.8 Document capability of Un-interruptible Power Source (UPS) for operation and capacity, sign off by Contractor.
 - 3.20.4.3.6.1.10.9 Document Graphics delivered to the Human Machine Interface (HMI) to Detailed Design Requirement with tabulated signoff and signed screen shots by the University of Toronto (IT), Contractor and Commissioning Authority.
 - 3.20.4.3.6.1.10.10 All above described documentation will be collated in order as listed above into a bound document and signed off by the Contractor, University of Toronto (IT) and the Commissioning Authority with a preface acceptance covering letter.

- 3.20.4.3.6.2 All Field Cx documentation and related test sheets shall be provided to F&S Project team, (preferably system wise) to commence verification and integration of the installed BAS system to the EMRS within 1 week after Cx Authority has completed their onsite static and functional verifications.
- 3.20.4.3.6.3 Upon receipt of the Installation Checklist document based on Section 3.21 of the Wiring Requirements and the written notice that includes EMRS BACNET Compliance Test Readiness form (3.20.4.6.3.1.8), F&S IT will conduct an on-site visit to carry out the following tasks:
 - 3.20.4.3.6.3.1 Verification of the Installation Checklist prior the site visit.
 - 3.20.4.3.6.3.2 Site visit with the visual verification of the Installation Checklist.
 - 3.20.4.3.6.3.3 Installation qualification of the BACnet compliance of the BAS DDC components. Read/write access, naming convention, alarm notifications.
- 3.20.4.3.6.4 Upon completion, a set of verification documents for the UOT Building Automation Design standards compliance, BACnet integration compliance, and network wiring compliance shall be provided.
- 3.20.4.3.6.5 The CxA shall coordinate with the contractor the Training of Building Engineers, and the Control and Automation staff. The training shall be structured to align with the requirements as provided in section 3.20.5 of this document. Delivering training modules A, B and C on a functional system are mandatory prior to the project reaching the mechanical building systems handover. Refer to section 3.20.5.2 of this document.

3.20.4.4 EMRS Compliance Testing Stage

- 3.20.4.4.1 This phase can be initiated only after deliverables related to 3.20.4.3.6 have been submitted in the single submission package and reviewed by F&S. Partial submissions and/or incomplete documentation sets are not acceptable.
- 3.20.4.4.2 The intent is to reduce the modification of tag references of points that are populated on the EMRS in the following phase.
- 3.20.4.4.3 This phase includes multiple testing procedures performed by F&S to ensure that the physical installation and the DDC software configuration complies with the UofT BAS Standard.
- 3.20.4.4.4 This phase includes the EMRS database design in order to create the real-time data acquisition. This includes the following:
 - 3.20.4.4.4.1 Auto-discovery of all the BACnet objects between the DDC field controllers and EMRS. This will create the actual licensing cost model that is mentioned in the Design/Pre-Tender Stage section 3.20.4.2.2 of this document.
 - 3.20.4.4.4.2 Verification of the naming convention and BACnet compliance.
 - 3.20.4.4.4.3 Download of all compliant BACnet Objects to the online database and the initial start of the historical data collection and the ability of EMRS to send out the alarm notifications to the existing list of recipients.
- 3.20.4.4.5 Upon completion of this phase a fully programmed EMRS for the real-time data acquisition with the ability of the EMRS operators to collect the historical data for trending and the EMRS operators' ability to receive the alarm notifications.

3.20.4.5 EMRS Graphical User Interface Programming Stage

- 3.20.4.5.1 This phase includes the programming of the EMRS Graphical User Interface (GUI) with dynamic data.
- 3.20.4.5.2 Upon completion of this stage, Training Module D shall be conducted to all UOT Operational staff.
- 3.20.4.5.3 The operators and the Cx Authority can then use the developed programmed set of the EMRS Graphical User Interface.
- 3.20.4.5.4 Upon completion of EMRS GUI, Cx Authority will complete necessary GUI Functional verifications on the EMRS and provide review report to F&S Project team.
- 3.20.4.5.5 Cx Authority will also collect the required information to develop a Systems Manual to the F&S Project team for review and onward submission to Building Operations.
- 3.20.4.5.6 The BAS contractor's temporary GUI database backup will be provided to F&S Project Team and related hardware will be decommissioned from the network.

3.20.4.6 Final Tune Up Stage

- 3.20.4.6.1 Upon completion and availability of the final set of the as-built drawings, final tuning of the EMRS GUI can commence by F&S IT.
- 3.20.4.6.2 Updated As built as a result of final tune-up will be submitted by the BAS contractor to Cx Authority and Design Engineer for review.
- 3.20.4.6.3 The final Operation and Maintenance Manual will be developed following section 1.11.12 of the UOT Building Automation Design standards.
- 3.20.4.6.4 Cx Authority will provide an assimilated Cx report, which will include all field Cx documentation and certificate of completion and handover as per Overall Building Commissioning standard.

3.20.5 TRAINING

3.20.5.1 General

- 3.20.5.1.1 This section describes the Structure of the training requirements for the UofT Operations Staff. It consists of four modules that are to be conducted at two stages of the EMRS Integration Process. The CxA will develop a course outline along with the contractor using the training plan structure described below and include training dates in Cx Schedule.
- 3.20.5.1.2 Stage 1 which includes Modules A, B and C is a prerequisite for occupancy and/or the mechanical building systems handover.
- 3.20.5.1.3 Stage 2 which include Modules D can be subsequent to the EMRS GUI programming stage, described in section 3.20.4.5.

3.20.5.2 Training Plan

Module A: Operation Training Part I

1. Review the as building control drawing.
2. Review list of control system components.
3. Review list of points and objects.
4. Review device and Network Communication Architecture
5. A walk-through of the mechanical system and installed DDC components (controllers, valves, dampers, sensors, etc.).
6. A discussion of the components and functions at each DDC panel
7. Operational use of Portable operator's terminal.

Attendees: Building Engineers, Automation and Control

Trainer: BAS Vendor's Specialist

Witness: Commissioning Agent

Module B: Operations Training Part II (via temporary workstation)

1. Review sequence of operations, control functions and alarm functions.
2. Cover logging –in and navigating the system graphics.
3. Modifying set points.
4. Event management and scheduling.
5. Override control devices capabilities
6. Alarm capabilities and acknowledge protocols.
7. Troubleshooting strategies.
8. Trends set up.

Attendees: Building Engineers, Automation and Control

Trainer: BAS Vendor's Specialist

Witness: Commissioning Agent

Module C: Servicing & Programming DDC Training

1. BACnet fundamentals (objects, services, addressing) and how/where they are used in this project.
2. Modifying and downloading control program changes.
3. Creating, editing and viewing alarms.
4. Backing-up and restoring programming and database modification.
5. Adding and removing network devices.
6. System malfunction diagnostics and maintenance.
7. Troubleshooting hardware errors.
8. Custom application programming software.
9. Point objects addressing and commanding.
10. Custom Reporting.
11. Review of customized project specific control logic used in the DDC programs

Attendees: Control Techs

Trainer: BAS Vendor's Specialist

Witness: Commissioning Agent

Module D: Operations Training Part II (through EMRS)

1. Review sequence of operations, control functions and alarm functions specific to the project
2. EMRS refresher and building specific ;
 - a. Cover logging –in and navigating the system graphics.
 - b. Modifying set points.
 - c. Event management and scheduling.
 - d. Override control devices capabilities.
 - e. Alarm capabilities and acknowledge protocols.
 - f. Troubleshooting strategies.
 - g. Trends set up.

Attendees: Building Engineers, Automation and Control

Trainer: UofT F&S – EMRS Specialist, BAS Vendor's Specialist

Witness: Commissioning Agent

PART 1 - GENERAL

1.1 Submittals

- .1 **Shop Drawings/Product Data:** Submit shop drawings/product data sheets to the regulatory authority for review and approval prior to submitting to the Consultant. Conform to the following requirements:
 - .1 submit shop drawings/product data sheets for all products specified in this Section except pipe and fittings;
 - .1 Sprinklers shall be referred to on drawings and product submittals and be specifically identified by the manufacturer's listed model or series designation. Trade names and other abbreviated listings are not allowed.
 - .2 submit complete white print CAD layout drawings indicating the source of water supply with test flow and pressure, "head-end" equipment piping schematic, pipe routing and sizing, sprinkler heads layout and zones, all signed and sealed by a qualified professional mechanical engineer as specified below;
 - .3 submit copies of all calculations, including hydraulic calculations, stamped and signed by the same engineer who signs the layout drawings, and a listing of all design data used in preparing the calculations, system layout and sizing, including occupancy-hazard design requirements;
 - .4 in addition to submitting shop drawings to the regulatory authority as specified above, shop drawings must be approved by the Owner's insurer prior to being submitted to the Consultant for review.
- .2 **Test Certificate:** Submit a complete sprinkler system test certificate as specified in Part 3 of this Section.

1.2 Quality Assurance

- .1 **Codes and Standards:** Fire protection standpipe system work is to be in accordance with the following Codes and Standards:
 - .1 NFPA 13, Standard for the Installation of Sprinkler Systems;
 - .2 NFPA 25 Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems)
 - .3 NFPA 70 National Electrical Code.
 - .4 NFPA 72 National Fire Alarm Code.
 - .5 National Building Code.
 - .6 National Fire Code
 - .7 CAN/ULC-S524 (Standard for the Installation of Fire Alarm Systems)
 - .8 CAN/ULC-S537 (Standard for the Verification of Fire Alarm Systems)
 - .9 Requirements of authority having jurisdiction (AHJ).
 - .10 CSA B137.2, PVC Injection-Molded Gasketed Fittings for Cold-Water Pressure Services;
 - .11 CSA B137.3, Rigid Polyvinyl Chloride (PVC) Pipe for Pressure Applications;

- .12 ASTM A53, Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc Coated, Welded and Seamless;
 - .13 ASTM A135, Standard Specification for Electric-Resistance-Welded Steel Pipe;
 - .14 ASTM A234, Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service;
 - .15 ASTM A536, Standard Specification for Ductile Castings;
 - .16 ASTM A795, Standard Specification for Black and Hot-Dipped Zinc Coated (Galvanized) Welded and Seamless Steel Pipe for Fire Protection Use;
 - .17 ANSI/ASME B16.4, Grey Iron Threaded Fittings (Classes 125 and 250);
 - .18 CAN/CSA B64.10, Backflow Preventers and Vacuum Breakers.
- .2 **Subcontractor and Site Personnel:** Fire protection sprinkler work is to be performed by a sprinkler company who is a member in good standing of the Canadian Automatic Sprinkler Association. All site personnel are to be sprinkler fitters licensed in the jurisdiction of the work and under the continuous supervision of a foreman who is an experienced fire protection system installer and a journeyman pipe fitter.
- .3 **Dimensions and Coordination:** Check and verify all dimensions and conditions at the site and ensure that the work can be performed as indicated. Co-ordinate fire protection sprinkler work with all trades at the site and accept responsibility for and the cost of making adjustments to piping and/or spacing to avoid interference with other building components.
- .4 **Existing Sprinkler Work:** Verify the working condition of all existing fire protection sprinkler system equipment which has direct interface with the new work and is to remain. Replace with new equipment where necessary.
- .5 All system components must be UL and/or ULC listed and labelled.
- .6 All grooved couplings, and fittings, valves and specialties shall be the products of a single manufacturer.
- .7 All castings used for coupling housings, fittings, valve bodies, etc., shall be date stamped for quality assurance and traceability.

1.3 Design Requirements

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

1.4 Monitoring of Systems

- .1 In areas that remain occupied and used by Owner during Work, daily monitor and supervise existing fire protection systems serving renovation/working areas. Ensure that 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, system to ensure that it is in proper working condition;
 - .2 if portions of system are not in proper working order, provide supervisory personnel to monitor systems for area affected;
 - .3 document and sign off with Owner's representative signing off also, each respective daily check condition;
 - .4 ensure that work to system does not affect portion of system serving areas outside of renovation/working areas.

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:** Schedule 40 mild black carbon steel, ASTM A53, Grade B, complete with grooved ends and mechanical fittings and couplings equal to Victaulic "FireLock" fittings and Victaulic Style 009N, 107H, and 107N QuickVic and 005 rigid coupling joints. Strap type outlet fittings such as Victaulic "Snap-Let" are not acceptable.
 - .2 **Schedule 40 Steel – Screwed and Welded Joints:** 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.
 - .3 **Copper – Solder Joint:** Type "L" hard drawn seamless copper to ASTM B88, complete with copper solder type fittings to ASME/ANSI B16.18 and soldered joints.
- .2 **Mechanical Couplings:** Manufactured in two segments of cast ductile iron, conforming to ASTM A-536, Grade 65-45-12. Gaskets shall be pressure-responsive synthetic rubber, grade to suit the intended service, conforming to ASTM D-2000. Mechanical Coupling bolts shall be zinc plated (ASTM B-633) heat treated carbon steel track head conforming to ASTM A-449 and ASTM A-183. Couplings shall comply with ASTM F1476 – Standard Specification for Performance of Gasketed Mechanical Couplings for Use in Piping Applications.
 - .1 **Rigid Type:** Coupling housings with offsetting, angle-pattern bolt pads shall be used to provide system rigidity and support and hanging in accordance NFPA-13. Couplings shall 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, equal to Victaulic Style 177 (Quick-Vic).

2.2 Shut-Off Valves

- .1 Equal to Victaulic Style 705, minimum 300 psi rated full port brass or bronze body screwed ball valves and lug body or grooved end type butterfly valves.
- .2 Butterfly valves shall include a pressure responsive seat, and the stem shall be offset from the disc centreline to provide complete 360-degree circumferential seating.

2.3 OS&Y Gate Valves

- .1 Equal to Victaulic Series 771H (grooved ends) and Series 771F (grooved x flanged), rated minimum 250 psi (1725 kPa), 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.

2.4 Check Valves

- .1 Equal to Victaulic Series 717, minimum 250 psi resilient seat check valves, suitable for vertical or horizontal installations.
- .2 Check valves associated with Fire Department connections and fire pump test connection are to be tapped for site installation of a 3/4" diameter ball drip.

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 with each complete with all required mounting and connection hardware.
- .2 Actuator housings shall be weatherproof.

2.6 Water Flow Alarm Switch

- .1 Pipe mounting water flow alarm switch, minimum 250 psi rated, designed to actuate two 7 ampere rated (at 125/250 VAC) SPDT snap action switches when water flow exceeds 10 gpm, complete with a tamper-proof cover with conduit connection opening, a piping saddle and U-bolt, and an automatic reset pneumatic retard device with field adjustable (0 to 70 second) switch actuation delay to reduce false alarms caused by a single or series of transient water flow surges.

2.7 Zone Control Riser Modules

- .1 Equal to Victaulic Co. "FireLock" Series 747M factory assembled zone control riser modules, each complete with a painted cast ductile iron grooved end body, a ball type shut-off valve, a test and drain combination with properly sized orifice, a flow alarm switch, a pressure gauge with cock, and a pressure relief valve kit.
- .2 **Cabinets:** Zone flow test and drain assembly cabinets are to be equal to National Fire Equipment Ltd. Model CV-200 recessed cold rolled steel cabinets, sized to suit the assemblies, with a baked enamel finish, #18 gauge with universal knockouts for tubs, #14 gauge for doors and trim, with all metal edges ground and rounded. Doors are to be 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 a flush stainless steel door latch.

2.8 Sprinkler Heads

- .1 Sprinkler heads, unless otherwise specified, are to be as scheduled in Part 3 of this Section.
- .2 Sprinkler body shall be die-cast, with a hex-shaped wrench boss integrally cast into the sprinkler body to reduce the risk of damage during installation. Wrenches shall be provided by the sprinkler manufacturer that directly engages the wrench boss.
- .3 For locations where corrosive resistant coatings are required, body shall be coated with UL listed and FM approved anti-corrosion VC-250 coating (silver colouring).
- .4 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.
- .5 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.
- .6 Sprinkler heads located in areas or over equipment where high ambient temperature is present are to be, unless otherwise specified, 165°F heads. All other heads, unless otherwise specified or required, are to be 135°F rated.
- .7 Escutcheons and guards shall be listed, supplied, and approved for use with the sprinkler by the sprinkler manufacturer.
- .8 Acceptable sprinkler head manufactures are:
 - .1 Tyco Fire Suppression & Building Products;
 - .2 Victaulic Co.;
 - .3 The Viking Corporation;
 - .4 The Reliable Automatic Sprinkler Co.

2.9 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 a full complement of spare sprinkler heads.
- .2 The cabinet is to be sized to accommodate a minimum of six (6) spare heads for each type of head used on the project, however, each cabinet is to be full of spare heads.

PART 3 - EXECUTION

3.1 Demolition

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

3.2 Piping Installation Requirements

- .1 Provide all required sprinkler system piping.

- .2 Do all 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 piping inside the 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 2" diameter, screwed fittings and joints, or, for piping 2½" diameter and larger, welding fittings and welded joints;
- .4 Exceptions to piping requirements specified in previous article are as follows:
 - .1 all dry pipe zone steel piping, fittings, unions, couplings and flanges are to be galvanized;
 - .2 all wet zone steel piping, fittings, unions, couplings and flanges for sprinkler work exposed to weather either inside or outside the building are to be galvanized;
 - .3 PVC piping is not to be used above grade;
 - .4 all ferrous pipe hangers, supports, and similar hardware used for galvanized steel piping are to be electro-galvanized.
- .5 All pipe sizes, pipe routing, sprinkler head quantities and locations, and layout of work shown on the drawings are to assist you during the tendering period. Ensure adequate head coverage, head quantities and pipe sizing as specified in Part 1 of this Section. Do not reduce the size of the sprinkler main or re-route the main unless approved.
- .6 All pipe, fittings, couplings, flanges and similar components are to be clean after erection is complete. Any ferrous pipe, fitting, coupling, flange, hanger, support and similar component which exhibits rust is to be wire brush cleaned and carefully coated with suitably coloured primer.
- .7 Grooved joints shall be installed in accordance with the manufacturer's latest published installation instructions. Grooved ends shall be clean and free from indentations, projections, and roll marks. Gaskets shall be moulded and produced by the coupling manufacturer and shall be verified as suitable for the intended service. A factory-trained field representative of the mechanical joint manufacture shall provide on-site training for contractor's field personnel in the proper use of grooving tools and installation of grooved piping products. The factory-trained representative shall periodically review the product installation and ensure best practices are being followed. Contractor shall remove and replace any improperly installed products.
- .8 When sprinkler work is complete, test system components and the overall system(s) and submit completed test certificate and other documentation in accordance with Chapter 8 of NFPA 13.

3.3 Installation of Shut-Off Valves and Check Valves

- .1 Provide shut-off valves and check valves in piping where shown, and wherever else required.
- .2 Locate all valves for easy operation and maintenance.
- .3 Confirm exact locations prior to roughing-in.

3.4 Installation of Shut-Off Valve Supervisory Switches

- .1 Equip each shut-off valve with a supervisory switch.

- .2 Identify each supervised valve with a 6" square, engraved, laminated red-white plastic tag to correspond with supervised valve numbering specified and/or shown as part of the electrical work fire alarm system.

3.5 Installation of Flow Alarm Switches

- .1 Provide water flow alarm switches in accessible locations in zone piping where shown.
- .2 Adjust to suit site water pressure conditions. Check and test operation.
- .3 Identify each switch with a 6" square red-white laminated engraved plastic tag. Confirm wording prior to engraving.

3.6 Installation of Zone Control Riser Modules

- .1 Provide zone control riser modules with drain piping where required. Terminate drainage piping over a funnel floor drain or mop sink unless otherwise shown or specified. Identify each assembly.

3.7 Installation of Zone Control Riser Module Cabinets (SVC)

- .1 Provide flush wall mounting cabinets for zone control and inspector's test connection assemblies where required in finished areas. Confirm exact locations prior to roughing-in.
- .2 Identify each cabinet with a nameplate as per requirements of the mechanical work Section entitled Basic Mechanical Materials and Methods.

3.8 Installation of Sprinkler Heads

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

3.9 Installation of Spare Sprinkler Head Cabinet

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

END OF SECTION

PART 1 - GENERAL

1.1 Submittals

- .1 **Shop Drawings/Product Data:** Submit shop drawings/product data sheets for all products specified in Part 2 of this Section except for pipe and fittings, and chlorine.
- .2 **Water Purity Data:** Submit laboratory water purity test results indicating chlorine residual prior to application for Substantial Performance.

1.2 Quality Assurance

- .1 Domestic water piping and valves are to comply with following codes, regulations and standards (as applicable):
 - .1 applicable local codes and regulations;
 - .2 CAN/CSA B125.1, Plumbing Supply Fittings;
 - .3 CAN/CSA B125.3, Plumbing Fittings;
 - .4 CAN/CSA B137 Series, Thermoplastic Pressure Piping Compendium;
 - .5 NSF/ANSI 14, Plastics Piping System Components and Related Materials;
 - .6 NSF/ANSI 61, Drinking Water System Components – Health Effects;
 - .7 NSF/ANSI 372, Drinking Water System Components – Lead Content.

PART 2 - PRODUCTS

2.1 Pipe, Fittings and Joints

- .1 **Soft Copper:** Type "K" soft copper to ASTM B88, supplied in a continuous coil with no joints if possible, and complete with, if joints are required, compression type flared joint couplings,
- .2 **Hard Copper - Solder Joint:** Type "L" hard drawn seamless copper to ASTM B88, complete with copper solder type fittings to ASME/ANSI B16.18 and soldered joints using The Canada Metal Co. Ltd. "SILVABRITE 100" or equal lead-free solder for cold water pipe, and 95% tin/5% Antimony or "SILVABRITE 100" solder for other services.
- .3 **Hard Copper - Grooved End Mechanical Joint:** Type "L" hard drawn seamless copper to ASTM B88, factory or site roll grooved, complete with Victaulic grooved end fittings. 607 QuickVic couplings, consisting of ductile iron housings to ASTM A 536 (Grade 65 45 12) with coating of copper alkyd enamel paint.
- .4 **Copper Pressure Coupled Joint:** Type "L" hard drawn seamless copper to ASTM B88 with "ProPress with Smart Connect feature" copper fittings with EDPM seals, and pressure type crimped joints made by use of a Rigid Tool Co. Model RP 330 or Model RP 210 electro-hydraulic crimping tool.

2.2 Shut-Off Valves

- .1 **Ball Valves:** Class 600, 600 psi WOG rated full port ball type valves, each complete with a forged brass body with solder ends, forged brass cap, and blowout-proof stem, solid forged brass chrome plated ball, "Teflon" or "PTFE" seat, and a removable lever handle. Valves in insulated piping are to be complete with stem extensions. Acceptable products are:
 - .1 Toyo Valve Co. Fig. 5049A;
 - .2 Milwaukee Valve Co. #BA-155;
 - .3 Kitz Corporation Code 59;
 - .4 Apollo Valves # 77-200;
 - .5 Watts Industries (Canada) Inc. #FBVS-3.
 - .6 Challenger
 - .7 Zurick
- .2 **Butterfly Valves - Flanged Joint:** Non-corrosive, ANSI Class 125 minimum 175 psi cold water pressure rated, resilient seated butterfly valves, each complete with a coated cast ductile iron lug type body, stainless steel shaft, bronze disc, and EPDM seat, and each suitable for domestic water bubble-tight dead-end service with the valve in position and either side of the connecting piping removed. Butterfly valves to and including 4" dia. are to be equipped with lever handles. Butterfly valves larger than 4" dia. are to be equipped with worm gear operators. Acceptable products are:
 - .1 DeZurik #632L Series;
 - .2 Kitz Corporation Code #6122EL/EG;
 - .3 Toyo Valve Co. #918BESL/EG;
 - .4 Bray Valve and Controls Canada Series 31 / 31H;
 - .5 Apollo Valves # 143 Series;
 - .6 Watts Industries (Canada) Inc. #BF-03.
- .3 **Butterfly Valves – Grooved End:** Equal to Victaulic Style 608N, rated for pressure range from full vacuum to 300 psi/2065 kPa and for bi-directional, dead end services to full working pressure UL Classified in accordance with ANSI/NSF 61 for ambient +86°F/+30°C and hot +180°F/+82°C potable water service and ANSI/NSF 372.

2.3 Check Valves

- .1 **Horizontal:** Class 125, bronze 200 psi WOG rated horizontal swing type check valves with solder ends. Acceptable products are:
 - .1 Toyo Valve Co. Fig. 237;
 - .2 Milwaukee Valve Co. #1510;
 - .3 Kitz Corporation Code 23;
 - .4 Apollo Valves # 61-600.

-
- .2 **Vertical:** Equal to Kitz Corp. Code 26, bronze, 250 psi WOG rated vertical lift check valve with soldering ends.

2.4 Drain Valves

- .1 Minimum 300 psi water rated, $\frac{3}{4}$ " dia., straight pattern full port bronze ball valves, each complete with a threaded outlet suitable for coupling connection of $\frac{3}{4}$ " dia. garden hose, and a cap and chain. Acceptable products are:
 - .1 Toyo Valve Co. Fig. 5046;
 - .2 Dahl Brothers Canada Ltd. Fig. No. 50. 430;
 - .3 Kitz Corporation Code 58CC;
 - .4 Apollo Valves # 78-104-01;
 - .5 Watts Industries (Canada) Inc. #B6000-CC.

2.5 Domestic Hot Water Piping Manual Balancing Valves

- .1 Solder or flanged end type 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 Tour and Andersson Model Series 786 or 787;
 - .2 Armstrong Fluid Technology Model CBV Series;
 - .3 Watts Industries (Canada) Inc. Model CSM Series.

2.6 Domestic Hot Water Pressure Independent Piping Balancing Valves

- .1 Equal to Tour & Andersson TCP Pressure Independent Balancing & Control Valve, rated for 230 psi, NPT threaded ends, non-ferrous Ametal® DZR brass copper alloy body, PPS (polyphenylsulfide) plug, EPDM o-ring seat and spindle seal, stainless steel return spring, Nedox® coated Ametal® spindle, HNBR membrane, and 10-position setting dial.
- .2 Valve shall be designed for modulating control of hot water re-circulation systems suitable for control, pre-setting (of flow), differential pressure control, measuring, shut-off, and flushing.
- .3 Suitable for working temperatures to +250°F (+120°C). Body material shall be ISO 6509 compliant.

2.7 Chlorine

- .1 Sodium hypochlorite to AWWA B-300-75.

2.8 Domestic Water Piping and Valves

- .1 For piping 65 mm (2-1/2") diameter and larger, non-corrosive pilot operated pressure reducing valve to CAN/CSA B356, factory set at the required pressure, field adjustable, and complete with a bronze body and trim, screwed or flanged connections, and brass body pilot valve with stainless steel seat. Acceptable products are:
 - .1 Singer Valve Model 106 PR;
 - .2 Zurn/Wilkins Model ZW109;

- .3 Watts Industries (Canada) Inc. Series N223;
- .4 Victaulic Co. (Bermad).

PART 3 - EXECUTION

3.1 Piping Installation Requirements

- .1 Provide all required domestic water piping.
- .2 Piping, unless otherwise specified, is to be as follows:
 - .1 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 Slope all piping so that it can be completely drained.
- .4 Provide proper dielectric unions in all connections between copper pipe and ferrous pipe or equipment. Dielectric unions are to conform to ASTM F1545-97 and are to be complete with a thermoplastic liner.

3.2 Installation of Shut-Off and Check Valves

- .1 Refer to Part 3 of the mechanical work Section entitled Basic Mechanical Materials and Methods.

3.3 Installation of Drain Valves

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

3.4 Installation of Domestic Hot Water Piping Balancing Valves

- .1 Provide balancing valves in domestic hot water recirculation piping where shown or required. Balancing valves to be provided as follows:
 - .1 Piping up to and including 1": Pressure Independent Balancing Valves
 - .2 Piping greater than 1": Manual Balancing Valves
- .2 Locate each valve such that it is easily accessible.

3.5 Installation of Pressure Reducing Valves

- .1 Provide domestic water pressure reducing valves in piping where shown and/or required. Install so that each valve is readily accessible. Whenever possible, provide pressure reducing valves factory preset to required pressures.
- .2 Check and test operation and adjust as required.

3.6 Flushing and Disinfecting Piping

- .1 Flush and disinfect all new and/or reworked 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 all foreign materials have been removed and the 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 the piping with a solution of chlorine in accordance with AWWA C601.
 - .5 When disinfecting is complete, submit water samples to a certified laboratory for purity testing and, when testing indicates pure water in accordance with governing standards, submit a copy of the test results and fill the systems.

END OF SECTION

PART 1 - GENERAL

1.1 Submittals

- .1 **Shop Drawings/Product Data:** Submit shop drawings/product data sheets for all products specified in Part 2 of this Section.
- .2 **Backflow Preventer Inspection/Test Results:** Submit signed test results and inspection and test log cards for each backflow preventer as specified in Part 3 of this Section.

PART 2 - PRODUCTS

2.1 Water Hammer Arrestors

- .1 Piston type, sealed, all stainless steel construction, pressurized water hammer arrestors suitable for either vertical or horizontal installation, each complete with a pressurized compression chamber, welded nesting-type expansion bellows surrounded by non-toxic mineral oil, and a male treaded nipple connection.
- .2 Acceptable products are:
 - .1 Jay R. Smith 5000 Series;
 - .2 Precision Plumbing Products "SS" Series.

2.2 BackFlow Preventers

- .1 Reduced Pressure Zone Assembly
 - .1 Lead-free reduced pressure zone assembly backflow preventer in accordance with CAN/CSA B64 (including supplements), each of bronze or epoxy coated cast iron bronze fitted construction depending on size, and complete with inlet strainer, inlet and outlet shut-off valves, an intermediate relief valve, ball valve type test cocks, and a proper air gap fitting.
 - .2 Acceptable products are:
 - .1 Watts Industries #LF009QT-S for 12 mm (½") size, #LF909QT-S for 20 mm to 50 mm (¾" to 2") size, and #LF909-NRS-S for 65 mm (2-½") and larger size;
 - .2 Zurn/Wilkins 975XL2 and 375 Series;
 - .3 "Apollo" Valves manufactured by Conbraco Industries Inc. Series 4ALF;
 - .4 Danfoss Flomatic Corp. Series RPZ.

2.3 Air Vents

- .1 Equal to ITT Hoffman Specialty No. 78 cast brass, 150 psi rated, ¾" straight water main vent valves, each tapped at the top for a 1/8" safety drain connection.

2.4 Domestic Water Thermal Expansion Tank

- .1 Pre-charged domestic water thermal expansion tank in accordance with Section VIII of the ASME Boiler and Pressure Code, carbon steel outer shell construction and complete with fixed butyl rubber bladder to prevent water from contacting shell interior, top NPT stainless steel system connection, 7.6 mm to 813 mm (0.301" to 32") charging valve connection and prime painted exterior.
- .2 Acceptable products are:
 - .1 Watts Industries (Canada) Inc. Series DETA;
 - .2 Zurn/Wilkins Model WTTA.

PART 3 - EXECUTION

3.1 Installation of Trap Seal Primers

- .1 Provide all required accessible trap seal primers to automatically maintain a water seal in floor drain traps, whether shown on the contract documents or not.
- .2 **Water Closet Flush Valves:** Water closet flush valves may be used for priming washroom floor drain traps if the flush tube is properly tapped and primer tubing exposed in the washroom is chrome plated.

3.2 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 the 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 required by Code.
- .2 Install each unit in a piping tee either horizontally or vertically in the path of potential water shock in accordance with the manufacturer's published instructions and details.

3.3 Installation of Backflow Preventers

- .1 Provide a reduced pressure zone assembly backflow preventer in each direct domestic water connection to equipment other than plumbing fixtures and fittings.
- .2 Locate each backflow preventer on floor or wall between 765 mm and maximum 1.5 m (30" and 60") above floor such that it is easily accessible for maintenance and testing. Equip each backflow preventer with an air gap fitting and pipe the reduced pressure zone water outlet to drain.
- .3 Test operation of each backflow preventer in accordance with requirements of CAN/CSA B64 by personnel certified for such testing by governing authorities, and submit signed test results and a properly and clearly identified and marked inspection and test record card for each backflow preventer.

3.4 Installation of Air Vents

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

3.5 Installation of Domestic Water Thermal Expansion Tank

- .1 Provide water thermal expansion tanks in domestic water piping where shown.
- .2 Unless otherwise specified, mount at least 18" from the cold water inlet to domestic water heater.
- .3 Adjust pre-charge to match incoming water pressure after installation.
- .4 Install in accordance with the manufacturer's instructions and as per local governing Codes and Regulations.

END OF SECTION

PART 1 - GENERAL

1.1 Submittals

- .1 **Shop Drawings/Product Data:** Submit shop drawings/product data sheets for all products specified in this Section except pipe and fittings.
- .2 **Plumbing Inspection Certificate:** Submit a copy of the plumbing inspection certificate prior to application for Substantial Performance.

PART 2 - PRODUCTS

2.1 Pipe, Fittings and Joints

- .1 **Copper- Solder Joint:** Type DWV hard temper to ASTM B306, with forged copper solder type drainage fittings and 50% silver - 50% tin solder joints.
- .2 **Cast Iron:** Class 4000 cast iron pipe, fittings, and mechanical coupling joints to CAN/CSA B70.

PART 3 - EXECUTION

3.1 Drain and Vent Piping Installation Requirements

- .1 Provide all required drainage and vent piping. Pipe, unless otherwise specified, is to be as follows:
 - .1 for pipe inside building and aboveground in sizes less than or equal to 65 mm (2-½") dia. – type DWV copper;
 - .2 for pipe inside building and aboveground in sizes greater than or equal to 75 mm (3") dia. – Class 4000 cast iron;
- .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.

END OF SECTION

PART 1 - GENERAL

1.1 Submittals

- .1 **Shop Drawings/Product Data:** Submit shop drawings/product data sheets for all products specified in this Section.

PART 2 - PRODUCTS

2.1 Cleanouts

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

2.2 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 the floor finish, a seal plug, and captive, vandal-proof, stainless steel securing hardware. Acceptable products are:
 - .1 Watts Industries (Canada) Ltd.;
 - .2 Jay R. Smith Manufacturing Co.;
 - .3 Zurn Industries Ltd.;
 - .4 Mifab Inc.
- .2 All 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.

2.3 Floor Drains, Funnel Floor Drains and Hub Drains

- .1 Unless otherwise specified or scheduled, floor drains and funnel floor drains are to be vandal-proof drains in accordance with the drawing schedule, each complete with a cast iron body and a trap seal primer connection. All cast iron components are to be factory finished with latex based paint coating.
- .2 All 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.
 - .1 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 Installation of Cleanouts

- .1 Provide cleanouts in drainage piping in locations as follows:
 - .1 in the building drain or drains as close as possible to the inner face of the outside wall, and, if a building trap is installed, locate the cleanout on the downstream side of the building trap;
 - .2 at or as close as practicable to the foot of each drainage stack;
 - .3 at maximum 50' intervals in horizontal pipe 4" dia. and smaller;
 - .4 at maximum 100' intervals in horizontal pipe larger than 4" dia.;
 - .5 wherever else shown on drawings.
- .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.

3.2 Installation of Floor Cleanout Terminations

- .1 Where cleanouts occur in horizontal inaccessible underground piping, extend the cleanout TY fitting up to the floor, and provide a cleanout termination set flush with the finished floor.
- .2 In waterproof floors, ensure that each cleanout termination is equipped with a flashing clamp device. Cleanout terminations are to suit the floor finish.
- .3 Where cleanout terminations occur in finished areas, confirm locations prior to rough-in and arrange piping to suit.
- .4 Ensure that cleanout termination covers in tiled floor are square in lieu of round.

3.3 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. Water supply from trap seal primers shall be type "K" hard copper tubing.
- .4 In equipment rooms and similar areas, exactly locate floor drains to suit the location of mechanical equipment and equipment indirect drainage piping. In washrooms, exactly locate floor drains to avoid interference with toilet partitions.
- .5 Confirm the 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 cleanup work and when requested, demonstrate free and clear operation of each drain. Replace any damaged grates, and refinish any areas of the drain where the cast iron finish has been damaged or removed, including rusted areas.

END OF SECTION

PART 1 – GENERAL

1.1 Submittals

- .1 **Product Data:** Submit product data sheets (fixture cuts) for all plumbing fixtures and fittings, including accessories. All product data sheets must confirm that the proposed fixtures and fittings meet all requirements of this Section of the Specification.
- .2 **Colour Charts:** Submit fixture manufacturer's standard colour charts for all 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 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, fittings and piping exposed to view are to be chrome plated and polished.
- .5 Fittings located in areas other than private washrooms are to be vandal-proof.
- .6 Fixture carriers are to be suitable in all respects for the fixture they support and construction in which they are located.
- .7 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.
- .8 Proper seal to mate with fixture carrier flange and produce a water-tight installation.
- .9 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.
- .10 Concealed traps for fixtures not equipped with integral traps, such as counter sinks, are to be adjustable cast brass with cleanout plugs, all to suit fixture type and drain connection.
- .11 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.
- .12 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 the fixture schedules as shown on drawings.

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;
 - .4 Moen Commercial.
 - .2 Plumbing Brass:
 - .1 Sloan;
 - .2 Acorn Engineering;
 - .3 American Standard;
 - .4 Delta Commercial;
 - .5 Chicago Faucet;
 - .6 Moen Commercial.
 - .3 Stainless Steel Sinks:
 - .1 Franke Commercial;
 - .2 Novanni Commercial;
 - .3 Aristaline;
 - .4 Arch Metal Inc.
 - .4 Mop Sinks:
 - .1 Stern Williams;
 - .2 Acorn Engineering;
 - .3 Zurn Industries.
 - .5 Drain Fittings, Angle Supplies, and Traps:
 - .1 McGuire;
 - .2 American Standard;
 - .3 Delta Commercial;
 - .4 Zurn Industries.
 - .6 Fixture Carriers:
 - .1 Watts Industries;

-
- .2 Jay R. Smith;
 - .3 Zurn Industries.
 - .7 Hose Bibbs:
 - .1 Jay R. Smith;
 - .2 Zurn Industries.
 - .8 Water Closets and Lavatories:
 - .1 American Standard;
 - .2 Zurn Industries;
 - .3 Kohler.
 - .9 Thermostatic Mixing Valves:
 - .1 Lawler;
 - .2 Delta Commercial;
 - .3 Leonard.
 - .10 Toilet Seats:
 - .1 Olsonite;
 - .2 Centoco;
 - .3 Bemis Commercial.
 - .11 Electronic "No Touch" Flush Valves:
 - .1 Sloan;
 - .2 Delta Commerical;
 - .3 Zurn Industries;
 - .4 Moen Commercial.

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.

PART 3 – EXECUTION

3.1 Installation of Plumbing Fixtures and Fittings

- .1 Provide required plumbing fixtures and fittings.
- .2 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)	-----
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)	-----
Prefab. Mop Sinks with Drain	75 (3)	38 (1-½)	20 (¾)	20 (¾)	-----

- .3 Confirm exact location of plumbing fixtures and trim prior to roughing-in. Refer to architectural plan and elevation drawings.
- .4 When installation is complete, check, and test operation of each fixture and fitting. Adjust or repair as required.
- .5 **Barrier-free fixtures:** Comply with mounting height and other requirements of governing Code(s).
- .6 **Counter Mounted Fixtures and Trim:** Supply templates for counter mounted fixtures and trim and hand to trades who will cut the counter. Ensure openings in counter are properly located.
- .7 **Electronic Lavatory Faucets:** 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.
- .8 For electronic flush valves, locate transformer in ceiling space above electronic units to be served. Coordinate locations with electrical trade who will provide 120 volt line supply to transformers. Provide low voltage wiring from transformers to each electronic flush valve terminal point. Electrical line supply and low voltage wiring is to be concealed and access to transformer must be provided for servicing.
- .9 **Mop Service Basins:** Set mop service basins on floor over drain piping and connect to roughed-in service. Install wall supply trim and any accessories specified.

3.2 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 the 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

PART 1 - GENERALS

1.1 Submittals

- .1 **Shop Drawings/Product Data:** Submit shop drawings/product data sheets for all products specified in this Section except pipe and fittings. The appropriate CRN assigned to each component is to be clearly indicated on the component shop drawing/product data sheet. Shop drawings and product data sheets must confirm that products proposed meet all requirements of this Section.
- .2 **Additional Data:** Submit product data sheets for all motors, and certified wiring diagrams for all equipment requiring power, control and/or alarm wiring connections.
- .3 **Pipe Joint Brazing Procedures:** Submit, prior to work commencing on site, a detailed account of your proposed pipe joint brazing procedures including pre and post nitrogen purging.
- .4 **Certification Reports:** Submit written certification by equipment manufacturers/ suppliers confirming that the equipment is properly installed, has been tested, and is in proper operating condition, all as specified in Part 3 of this Section.
- .5 **Start-Up Reports:** Submit manufacturer's start-up reports as specified in Part 3 of this Section.

1.2 Design Pressure and Temperature Requirements

- .1 System design pressures are as follows:
 - .1 **laboratory air:**
 - .1 maximum system pressure, 380 kPa (55 psi);
 - .2 maximum pressure at terminal unit, 345 kPa (50 psi).
 - .2 **laboratory vacuum:**
 - .1 maximum 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 All 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 Laboratory gas systems work must be performed by journeyman plumber/pipefitter / steamfitter tradesmen completely familiar with the 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. The 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.
- .3 The Consultant reserves the right to ask for and review the Certificate of any tradesman, and only tradesmen with valid Certificates may work on the systems.

PART 2 - PRODUCTS

2.1 General Re: Piping System Materials and Components

- .1 All 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 All 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 the component and piping is full of nitrogen.
- .3 **Acceptable Gas Product Manufacturers/Suppliers:** Unless otherwise specified, acceptable medical gas system product manufacturers/suppliers are:
 - .1 Class 1 Inc.;
 - .2 Amico Corp.;
 - .3 Beaconmedaes (Air Liquide)

2.2 Pipe, Fittings and Joints

- .1 **Above Ground:** 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.

2.3 Shut-Off Valves

- .1 Valves shall be of bronze body, double seal, full port, union ball-type with teflon (TFE) seats and Viton seals, "O" ring packing, bronze ball which seals in both directions, blow-out proof stem, having a pressure rating of 2758 kPa (400 psig).
- .2 Valves shall be operated by a lever handle requiring only a quarter turn from a fully open position to a fully closed position. All valves shall be equipped with type "K" washed and degreased copper pipe stub extensions at both the inlet and outlet sides of the valve port to facilitate installation.
- .3 Valves shall be designed so that it can be "swung-out" during installation to prevent damage due to heat transfer during the brazing operation. A UL listed label showing the appropriate gas services and pressure rating shall be attached to each valve.
- .4 Each valve assembly shall be provided washed and degreased for oxygen service and pipe stub extensions shall be capped at both ends. The valve shall be supplied in a sealed plastic bag to prevent contamination prior to installation.
- .5 Valves shall be ULC and CRN Listed. All valves shall have a locking device. Locks by others.

2.4 Laboratory Air Line Pressure Regulator

- .1 Simplex pressure reducing and regulating valve set, each, to C.S.A. Standard CAN/CSA Z7396.1, adjustable from 80 psi to 120 psi (552 kPa to 828 kPa), sized to the laboratory air supply main size and for 75 SCFM, capable of maintaining a constant dynamic supply pressure at system maximum design flow rate, factory cleaned and degreased, and shipped with capped ends.
- .2 Each pressure regulator shall be complete with a bronze body, an identification tag, a strainer, a large area diaphragm, renewable and accessible working parts, and a self-cleaning seat.

2.5 Signage & Labels

- .1 For each laboratory gas isolation valve, install a lamacoid nameplate secured to wall at ceiling.
- .2 Nameplate shall be 100 mm x 50 mm (4" x 2"), black letters on white background, indicating "Shut-Off Valve" and name of laboratory gas or laboratory vacuum.
- .3 All laboratory gas shut-off valves shall have a lamacoid nameplate attached by a chain to the valve handle indicating laboratory gas name and area served by valve and valve number. Label size shall be 80 mm x 50 mm (3" x 2").

PART 3 - EXECUTION

3.1 General Re: Piping Installation

- .1 All pipe joint brazing work must be done in accordance with CAN/CSA-Z7396.1 and reviewed brazing procedures submitted to the Consultant prior to the start of work.
- .2 The Consultant reserves the right to cut-out and examine piping joints during the course of the work or after the work is complete, and if the interior of the cut-out sample and/or fittings are found to be contaminated with oxidation or any other material the piping will be considered unacceptable and must be cleaned or replaced.

3.2 Installation of Laboratory Gas System Piping

- .1 Provide required laboratory 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 Whenever possible use pipes, valves and accessories that have been factory cleaned in accordance with CSA Standard Z7396-1 and all amendments. The ends of all factory cleaned materials shall be sealed using temporary caps. Thoroughly clean items not factory cleaned or which become contaminated, by washing in a hot solution of sodium carbonate or trisodium phosphate (proportion: one pound to three gallons of water or 33 g/litre). The use of organic solvents such as carbon tetrachloride is prohibited. Rinse materials thoroughly with clean, hot water.
- .3 **Piping Above Ground:** Piping above ground, unless otherwise specified, is to be Type "L" hard copper.

- .4 **Unions:** Provide threaded piping unions at all piping connections to source equipment. Do not silver braze unions. Braze a male NPT adaptor on the end of the pipe, wrap Teflon tape onto the adaptor (two threads back), and screw the union as tight as you can by hand, then with proper wrenches for final tightening. Do not over tighten.
- .5 **Pipe Brazing Operations:** In strict accordance with requirements of CAN/CSA-Z7396.1.
- .6 **Tools:** Ensure that all tools used during erection of the piping systems are kept clean and free from oil and grease.
- .7 **Hangers and Supports:** Support piping by means of support materials specified in the mechanical work Section entitled Basic Mechanical Materials and Methods, in accordance with requirements of Section 11.3 of CAN/CSA-Z7396.1 and with support spacing in accordance with Table 9 in CAN/CSA-Z7396.1.
- .8 **Piping Identification:** Refer to the mechanical work Section entitled Basic Mechanical Materials and Methods. Identify all piping system work, including valves, concealed and exposed, on a daily basis in accordance with requirements of CAN/CSA-Z7396.1.
- .9 **Vacuum Piping:** Install vacuum piping sloped to low points. Equip each low point, including the bottom of vertical risers, with drip pockets consisting of a full size pipe tee with one leg capped with a removable cap. Ensure that all drip points are accessible and indicated on as-built record drawings.
- .10 **Branch Tees and Valves:** As per CAN/CSA-Z7396.1, provide a full size branch tee with shut-off valve for each gas source (including vacuum) downstream of the main isolation valve.

3.3 Installation of Valves

- .1 Provide shut-off/isolation valves where shown on the Contract Documents and/or required by CAN/CSA-Z7396.1. Valves in piping 75mm (3") diameter and larger are to be butterfly type. All other 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 that all valves are located for easy access and operation.

3.4 Installation of Laboratory Air Line Pressure Regulator

- .1 Provide laboratory air line pressure regulator as indicated on the drawings.
- .2 Wall mount each assembly, in an accessible location where indicated, complete with inlet and outlet shut-off valves, and a safety relief valve and line pressure gauge immediately downstream of each regulator and upstream of the isolation valve.
- .3 When installation is complete, check the operation of each pressure regulator and adjust to delivery pressure requirements in accordance with CAN/CSA Z7396.1.

3.5 Piping System Leakage and Pressure Testing

- .1 After erection of piping, and before installation of outlet valve stations, blow lines clear by means of oil-free, dry compressed air or nitrogen. Subject each section of each system to a test pressure of 150 psi (1034 kPa) for 24 hours by means of oil-free, compressed air or nitrogen. Maintain this test pressure until each joint has been examined for leakage by means of soap suds. Repair leaks and re-test sections. Maintain not less than 50 psi (345 kPa) during the remaining construction period. Supply the necessary test cylinders for testing purposes.
- .2 Pressure test each system independently. No interconnections between systems will be allowed.
- .3 Retain DMS Medical Gas Systems Inc. (Mr. Michael Stewart, tel. no. (416) 410-1716, mstewart.dms@gmail.com) to perform a final independent test of laboratory piping systems.
- .4 Make good each system not meeting the final test to the approval of the Testing Agency.

3.6 Joining Laboratory Gas Piping

- .1 Use only tradesmen holding a current TSSA Brazing and Pressure Vessel Certificate to do brazing work. Contractor must use TSSA, Pressure Vessels Safety Branch registered brazing procedure for medical gas piping.
- .2 Make copper-to-copper joints using Airosil 45 or equal silver brazing alloy conforming to AWS Standard BCUP-5. Use no flux.
- .3 Make copper-to-brass joints using Airosil flux or equal. Borax and alcohol mixture or resins and similar paste fluxes shall not be used.
- .4 Joint threaded fittings as outlined in CSA Standard Z7396-1.
- .5 Cut all piping accurately to site dimensions and assemble without springing or forcing.
- .6 During the brazing of pipe connections, purge the interior of the pipe continuously with nitrogen, except when making final connections.
- .7 Clean all pipe and fittings, which do not come pre-cleaned and factory sealed, in accordance with CSA Standard Z7396-1. Where flux is used, wash the outside of piping and fittings with hot water to remove residue flux.

3.7 Identification

- .1 Label all laboratory gas piping at 20' (6 metre) intervals maximum, at each side of walls and at least once in every room or small enclosed area as required by CSA Standard Z7396-1. This must be done on a daily basis as work progresses.
- .2 Use colour coding method which conforms to the CSA Standard Z7396-1.
- .3 Provide adhesive labels to identify the medical gas piping.
- .4 Identify all shut-off valves with lamacoid tags (see above). Each tag to be imprinted with both type of service and valve number. Use brass chains to attach tags to valves. Provide typewritten valve charts complete with schematic diagrams to identify location of each valve within the system.

3.8 Hangers

- .1 Do not support piping from other piping or equipment.
- .2 Use clevis hangers of the proper size and strength, fastened to the building structure. Provide dielectric separation as required.
- .3 Spacing of hangers shall be as listed below:

1/2" (15 mm)	6' maximum (1800 mm)
3/4" (20 mm)	8' maximum (2400 mm)
1" (25 mm)	8' maximum (2400 mm)
1-1/4" (32 mm) and larger	10' maximum (3000 mm)

3.9 Interference

- .1 Site measure space for available pipe space. Route piping to clear all other trades. Provide information for preparation of interference drawings.

3.10 Laboratory Gas Piping System Certification

- .1 When piping leakage testing as specified above is complete, retain DMS Medical Gas Systems Inc. as Certification Agency to certify the new work performed. Certification shall be in accordance with CAN/CSA-Z7396.1.
- .2 Arrange for the system installer to be part of the certification team.
- .3 Should Certification Agency be delayed by your default or by the fact that you are not ready for the certification procedure, or if scheduled certification is cancelled with less than two days' notice because the systems are not ready, you will be responsible for all costs for the Certification Agency to repeat the tests, remain on site longer than could reasonably be expected, or reschedule the tests, as applicable.
- .4 The 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.
- .5 Copies of all laboratory gas test results must be provided to the Owner for review and sign off in advance to turnover of space.

3.11 Record Drawings

- .1 Refer to Section 20 05 05.

3.12 System Training

- .1 Refer to Section 20 05 05.
- .2 Include for 1 site training sessions for a minimum of 6 people for 4 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

PART 1 - GENERAL

1.1 Section Includes

- .1 Supply and installation of processed water piping systems as described in this Section.

1.2 Quality Assurance

- .1 Perform all work in accordance with all applicable codes, specifications, standards and current editions of:
- .1 CAN/CSA Z317 series of Standards regarding the design, construction, testing, commissioning and operation of processed water piping systems, and all other codes and standards referenced therein.

PART 2 - PRODUCTS

2.1 R.O Water Piping

- .1 **Polyvinyl Chloride (PVC) pipe and fittings:** IPEX Schedule 80 pipe to ASTM D1784 Type 1, Grade 1, and ASTM D1785 and CSA B137.3, maximum operating temperature at 60C (140F) and pressure at 1000 kPa (145 psig). Pipe joints and fittings to be solvent welding socket fittings to ASTM D2467 and raised face flanges with flange bolts and nuts to ANSI B16.1 and flanged gaskets to ANSI B16.21 of neoprene 3mm thick. Pipe joint cold solvent to ASTM 2564. Elbows and tees wall thickness not less than that of pipe with which they are used, socket weld type, moulded to ASTM D2467 for NPS 8 and under; fabricated fiberglass reinforced to CGSB 41-22 and CSA B137.3 for NPS 10 and over.
- .2 **Valves**
 - .1 All ball valves in sizes ½" (20mm) through 2" (63mm) shall be IR butt fusion type 346 ball valves with PTFE/Teflon® ballseats & either EPDM or FPM/Viton® seals. All ball valves shall have a pressure rating of 150 psi /10 bar when measured at 68 oF/20 oC.

PART 3 - EXECUTION

3.1 Installation of Reverse Osmosis (R.O.) Water Piping

- .1 Provide all required RO water tubing. All work provided shall be in accordance with manufacturer's recommendations and CAN/CSA Z317.1-99.
- .2 Install fittings in accordance with fitting manufacturer's published instructions. Ensure pipe ends are square cut and reamed prior to insertion into fittings. Tighten fittings as instructed using fitting manufacturer's gauge.
- .3 Support tubing at maximum 5' (1.5m) intervals.
- .4 Disinfect and sterilize the piping system in accordance with the requirements

- of CAN/CSA Z317.1.
- .5 Provide shut-off valves at all connections to equipment.
 - .6 Slope RO water piping as for domestic water piping.
 - .7 When the piping has been properly flushed and cleaned, test with RO water or filtered dry compressed air in accordance with the pipe manufacturer's recommendations. Under no circumstances shall raw water be used for testing purposes. If distilled water is used as a testing medium, drain all water from the system when the test is complete. Test pressure shall be 100 psi (690 kPa) or as recommended by the piping system manufacturer, and maintained for a minimum of two (2) hours.
 - .8 Extend and connect piping to equipment.

END OF SECTION

PART 1 - GENERAL

1.1 Related Requirements

- .1 Division 23

1.2 Payment Procedures For Testing Laboratory Services

- .1 Engage and pay for services of independent testing laboratory in accordance with Division 01.

1.3 References

- .1 Definitions:
 - .1 HVAC System: complete air duct system from outside air intake louvers to furthest air supply terminal unit and including:
 - .1 Rigid supply and return ductwork;
 - .2 Flexible ductwork;
 - .3 Mixing plenum boxes;
 - .4 Return air plenums including ceiling plenums;
 - .5 Cooling and heating coils and compartments;
 - .6 Condensate drain pans, eliminator blades and humidifiers;
 - .7 Fans, fan blades and fan housing;
 - .8 Filter housing and frames;
 - .9 Acoustically insulated duct linings;
 - .10 Diffusers, registers and terminal units;
 - .11 Dampers and controls
 - .2 Reference Standards:
 - .1 Provide work in accordance with requirements of Regulatory Agencies and conform to the latest editions of:
 - .1 SMACNA HVAC Duct Construction Standards
 - .2 ASHRAE Duct Construction Recommendations.
 - .3 CSA-Z317.

1.4 Submittals

- .1 Shop Drawings/Product Data:
 - .1 Submit shop drawings/product data sheets for all products specified in Part 2 of this Section.
 - .2 Submit manufacturer's printed product literature and data sheets for antimicrobial agents and include product characteristics, performance criteria and limitations.
 - .3 Provide two copies of WHMIS MSDS in accordance with Division 01 Health and Safety Requirements for antimicrobial agents or coatings.
- .2 Submit video survey and cleaning plan developed during site evaluation.

- .1 Ensure plan includes sequence of operation, identification of camera and cleaning apparatus insertion points and schedule for work.
- .3 Testing Laboratory Services: submit name and address of laboratory engaged for work of this Section.
 - .1 Submit laboratory analysis report of particulate collection indicating:
 - .1 Location of collection;
 - .2 Particulate grade;
 - .3 Particulate size;
 - .4 Percentage concentration of individual particulates in each sample.

1.5 Closeout Submittals

- .1 Provide submittals in accordance with Division 01.
- .2 Reports:
 - .1 Submit two (2) copies of separate reports both before and after the cleaning procedure has been undertaken. Both reports shall include the following:
 - .1 Name of the facility and address
 - .2 Name and address of cleaning contractor
 - .3 Description of the ventilation system with drawings or clear neat sketches showing the various systems
 - .4 Identification scheme for all points in system that were examined and notes describing method of examination or testing used
 - .5 Where samples were analysed and type of analysis used
 - .6 Copy of scale chart showing scaling criteria
 - .7 Description and location of problem areas encountered and special or unusual situations or conditions and any comments or recommendations
 - .8 Results of analysis for all samples complete with corresponding scale rating
 - .9 Comments complete with photos illustrating each sampling location and other observed features of the system; and
 - .10 DVD format video tapes showing all areas tested for particulate analysis or microbial growth evaluation, all areas of special interest and general representative sections of the duct and components for each ventilation system cleaned.
 - .2 Submit two (2) copies of video tapes with each report. Reports shall be bound in binders, complete with index and title page. Further to the above requirements, the reports shall include the following:
 - .1 Preliminary Report: Video record or written description with locations of special internal features or potential problems such as broken or damaged controls or components, and recommended course of action with co-ordination that may be required, i.e. for sheet metal work, repair work, etc.
 - .2 Final Report: Similar to the before cleaning report, but reflecting more in-depth knowledge of systems after cleaning procedure has been completed.

1.6 Extra Materials

- .1 Extra Stock Materials:
 - .1 Supply 4 extra filters for each HVAC System cleaned.
 - .2 Ensure filters are correct match, size, type and configuration of existing HVAC Systems.

1.7 Quality Assurance

- .1 Contractor: verification of 5 years minimum experience in work similar to or exceeding work of this Section.
- .2 Project Co-ordinator: Air System Cleaning Specialist (ASCS) certified by NADCA on full time basis and/or verification of 5 years minimum experience in work similar to or exceeding work of this Section.

PART 2 - PRODUCTS

2.1 Vacuum Specification

- .1 Perform cleaning in accordance with SMACNA, CSA-Z317 and NADCA Standards for hospital environments.

PART 3 - EXECUTION

3.1 Ductwork To Be Cleaned

- .1 The following ductwork and equipment shall be cleaned under this Section:
 - .1 Ductwork and accessories provided under the Contract
 - .2 Air handling equipment provided under the Contract
 - .3 Air outlets and louvres provided under the Contract
 - .4 Plenums provided under the Contract
 - .5 Existing ductwork within the "Construction Area" of the Contract and at least 15 metres of existing ductwork beyond the area of the Contract.
 - .6 Existing duct mains and risers to which new ductwork has been connected under the Contract for a distance of at least 15 metres of existing ductwork beyond the area of the Contract.

END OF SECTION

PART 1 - GENERAL

1.1 Summary

- .1 Section Includes:
 - .1 Materials and methods for pressure testing ducts over 16'-0" (5000 mm) in length, forming part of a supply, return or exhaust ductwork system directly or indirectly connected to air handling equipment.
- .2 Related Sections:
 - .1 Section 20 05 40 - Mechanical Work Commissioning.

1.2 References

- .1 Comply with the latest edition of the following Codes and Standards.
- .2 Health Canada/Workplace Hazardous Materials Information System (WHMIS)
 - .1 Material Safety Data Sheets (MSDS).
- .3 Sheet Metal and Air Conditioning Contractor's National Association (SMACNA)
 - .1 SMACNA HVAC Air Duct Leakage Test Manual.

1.3 Submittals

- .1 Make submittals in accordance with Section 01 33 00 - Submittals.
- .2 Test Reports: submit certified test reports from approved independent testing laboratories indicating compliance with specifications for specified performance characteristics and physical properties. Include pressure test information and results as follows:
 - .1 Submit proposed report form and test report format to Consultant for review at least three months before proposed date of first series of tests. Do not start tests until approval received in writing from Consultant.
 - .2 Prepare report of results and submit to Consultant within 24 hours of completion of tests. Include:
 - .1 Schematic of entire system.
 - .2 Schematic of section under test showing test site.
 - .3 Required and achieved static pressures.
 - .4 Orifice differential pressure at test sites.
 - .5 Permissible and actual leakage flow rate (L/s) for test sites.
 - .6 Witnessed certification of results.
- .3 Include test reports in final TAB report.
- .4 Certificates: submit certificates signed by manufacturer certifying that materials comply with specified performance characteristics and physical properties.
- .5 Instructions: submit manufacturer's installation instructions.
- .6 Manufacturer's field reports specified.

PART 2 - PRODUCTS

2.1 Test Instruments

- .1 Test apparatus to include:
 - .1 Fan capable of producing required static pressure.
 - .2 Duct section with calibrated orifice plate mounted and accurately located pressure taps.
 - .3 Flow measuring instrument compatible with the orifice plate.
 - .4 Calibration curves for orifice plates used.
 - .5 Flexible duct for connecting to ductwork under test.
 - .6 Smoke bombs for visual inspections.
- .2 **Test apparatus:** accurate to within +/- 3% of flow rate and pressure.
- .3 Submit details of test instruments to be used to Consultant at least three months before anticipated start date.
- .4 **Test instruments:** calibrated and certificate of calibration deposited with Consultant no more than 28 days before start of tests.
- .5 Re-calibrated every six months thereafter.

2.2 Equipment Leakage Tolerances

- .1 Equipment and system components such as VAV boxes, duct heating leakage: 5%.

PART 3 - EXECUTION

3.1 Manufacturer's Instructions

- .1 Compliance: comply with manufacturer's written recommendations or specifications, including product technical bulletins, handling, storage and installation instructions, and datasheet.

3.2 Test Procedures

- .1 Maximum lengths of ducts to be tested consistent with capacity of test equipment.
- .2 Section of duct to be tested to include:
 - .1 Fittings, branch ducts, tap-ins.
- .3 Repeat tests until specified pressures are attained. Bear costs for repairs and repetition to tests.
- .4 Base partial system leakage calculations on SMACNA HVAC Air Duct Leakage Test Manual.
- .5 Seal leaks that can be heard or felt, regardless of their contribution to total leakage.

3.3 Site Tolerances

- .1 System leakage tolerances specified are stated as percentage of total flow rate handled by system. Pro-rate specified system leakage tolerances. Leakage for sections of duct systems: not to exceed total allowable leakage.

- .2 Leakage tests on following systems not to exceed specified leakage rates.
 - .1 Small duct systems up to 1" (250 Pa): leakage 2%.
 - .2 VAV box and duct on downstream side of VAV box: leakage 2%.
 - .3 Large low pressure duct systems up to 1.5" (500 Pa): leakage 2%.
 - .4 HP duct systems up to 3" (1000 Pa) pressure classification, including upstream side of VAV boxes: leakage 1%.
- .3 Evaluation of test results to use surface area of duct and pressure in duct as basic parameters.

3.4 Testing

- .1 **General:** In accordance with Section 20 05 40 - Mechanical Work Commissioning.
- .2 Test ducts before installation of insulation or other forms of concealment.
- .3 Test after seals have cured.
- .4 Test when ambient temperature will not affect effectiveness of seals, and gaskets.
- .5 Flexible connections to VAV boxes.

3.5 Field Quality Control

- .1 Performance Verification:
 - .1 The Consultant is to witness tests and to verify reported results.
 - .2 To be certified by same TAB agency approved by the Consultant to undertake TAB on this project.

3.6 Cleaning

- .1 Upon completion and verification of performance of installation, remove surplus materials, excess materials, rubbish, tools and equipment.

END OF SECTION

PART 1 - GENERAL

1.1 Summary

- .1 Related Sections:
 - .1 Section 20 05 05 - Common Work Results for Mechanical
 - .2 Section 20 05 40 – Mechanical Work Commissioning
 - .3 Section 20 05 50 - Testing, Adjusting and Balancing

1.2 References

- .1 Comply with the latest edition of the following Codes and Standards.
- .2 American Society for Testing and Materials International (ASTM)
 - .1 ASTM E202, Standard Test Methods for Analysis of Ethylene Glycols and Propylene Glycols.

1.3 Cleaning & Start-Up of Mechanical Piping Systems

- .1 In accordance with Section 23 08 02 - Cleaning and Start-up of Mechanical Piping Systems.

1.4 Hydronic Systems - Performance Verification (PV)

- .1 Perform hydronic systems performance verification after cleaning is completed and system is in full operation.
- .2 When systems are operational, perform following tests:
 - .1 Conduct full scale tests at maximum design flow rates, temperatures and pressures for continuous consecutive period of 48 hours to demonstrate compliance with design criteria.
 - .2 Verify performance of hydronic system as specified, recording system pressures, temperatures, fluctuations by simulating maximum design conditions and varying.
 - .1 Maximum cooling demand.
 - .2 Maximum heating demand.

1.5 Hydronic System Capacity Test

- .1 Perform hydronic system capacity tests after:
 - .1 TAB has been completed
 - .2 Verification of operating, limit, safety controls.
 - .3 Verification of primary and secondary pump flow rates.
 - .4 Verification of accuracy of temperature and pressure sensors and gauges.
- .2 Calculate system capacity at test conditions.
- .3 Using manufacturer's published data and calculated capacity at test conditions, extrapolate system capacity at design conditions.
- .4 When capacity test is completed, return controls and equipment status to normal operating conditions.
- .5 Submit sample of system water to approved testing agency to determine if chemical treatment is correct. Include cost.

- .6 Heating system capacity test:
 - .1 Perform capacity test when ambient temperature is within 10% of design conditions. Simulate design conditions by:
 - .1 Increasing OA flow rates through heating coils (in this case, monitor heating coil discharge temperatures to ensure that coils are not subjected to freezing conditions) or
 - .2 Reducing space temperature by turning of heating system for sufficient period of time before starting testing.
 - .2 Test procedures:
 - .1 Open fully heat exchanger, heating coil and radiation control valves.
 - .2 With hot water heating supply temperature stabilized, record flow rates and supply and return temperatures simultaneously.
- .7 Chilled water system capacity test:
 - .1 Perform capacity test when ambient temperature is within 10% of design conditions. Simulate design conditions by:
 - .1 Adding heat from building heating system or;
 - .2 Raising space temperature by turning off cooling and air systems for sufficient period of time before starting testing and pre-heating building to summer design space temperature (occupied) or above. Set OAD and RAD for minimum outside air if OAT is near outside design temperature or to maximum recirculation if RAT is greater that OAT. RAT to be at least 23 degrees C minimum.
 - .2 Test procedures:
 - .1 Open fully cooling coil control valves.
 - .2 Set thermostats on associated AHU's for maximum cooling.
 - .3 Set AHU's for design maximum air flow rates.
 - .4 Set load or demand limiters on chillers to 100%.
 - .5 After system has stabilized, record chilled water, and condenser water flow rates and supply and return temperatures simultaneously.

1.6 Potable Water Systems

- .1 When cleaning is completed and system filled:
 - .1 Verify performance of equipment and systems as specified elsewhere in Division 23.
 - .2 Check for proper operation of water hammer arrestors. Run one outlet for 10 seconds, then shut of water immediately. If water hammer occurs, replace water hammer arrestor or recharge air chambers. Repeat for each outlet and flush valve.
 - .3 Confirm water quality consistent with supply standards, verifying that no residuals remain resulting from flushing and/or cleaning.

1.7 Wet & Dry Pipe Sprinkler System, Standpipe & Hose Systems

- .1 Cleaning, testing, start-up, performance verification of equipment, systems, components, and devices is specified elsewhere in Division 23.
- .2 Verification of controls, detection devices, alarm devices is specified Division 26.
- .3 Verify operation of interlocks between HVAC systems and fire alarm systems.

1.8 Sanitary & Storm Drainage Systems

- .1 Buried systems: perform tests prior to back-filling. Perform hydraulic tests to verify grades and freedom from obstructions.
- .2 Ensure that traps are fully and permanently primed.
- .3 Ensure that fixtures are properly anchored, connected to system.
- .4 Operate flush valves, tank and operate each fixture to verify drainage and no leakage.

1.9 Reports

- .1 In accordance with Section 20 05 40 - Mechanical Work Commissioning, supplemented as specified herein.

1.10 Training

- .1 In accordance with Section 20 05 40 - Mechanical Work Commissioning, supplemented as specified herein.
 - .1 Include following:
 - .1 Humidifier operation.
 - .2 Air vent operation.
 - .3 Control valve operation.

PART 2 - PRODUCTS

2.1 Not Used

PART 3 - EXECUTION

3.1 Not Used

END OF SECTION

PART 1 - GENERAL

1.1 Summary

- .1 Section Includes:
 - .1 Procedures and cleaning solutions for cleaning mechanical piping systems.
- .2 Related Sections:
 - .1 Section 20 05 05 - Common Work Results for Mechanical

1.2 References

- .1 Comply with the latest edition of the following Codes and Standards.
- .2 American Society for Testing and Materials International (ASTM)
 - .1 ASTM E202, Standard Test Methods for Analysis of Ethylene Glycols and Propylene Glycols.
- .3 Health Canada/Workplace Hazardous Materials Information System (WHMIS)
 - .1 Material Safety Data Sheets (MSDS).

1.3 Submittals

- .1 Product Data:
 - .1 Submit manufacturer's printed product literature, specifications and datasheet in accordance with section 01 33 00 - Submittals. Include product characteristics, performance criteria, and limitations.
 - .1 Submit two (2) copies of Workplace Hazardous Materials Information System (WHMIS) Material Safety Data Sheets (MSDS) in accordance with Section 01 33 00 - Submittals.
- .2 Quality assurance submittals: submit following in accordance with Section 01 33 00 - Submittals.
 - .1 Certificates: submit certificates signed by manufacturer certifying that materials comply with specified performance characteristics and physical properties.
 - .2 Instructions: submit manufacturer's installation instructions.

1.4 Delivery, Storage, & Handling

- .1 Packing, shipping, handling and unloading:
 - .1 Deliver, store and handle materials in accordance with manufacturer's written instructions.

PART 2 - PRODUCTS

2.1 Cleaning Solutions

- .1 **Tri-sodium phosphate:** 0.9 lbs per 26.5 gallons (0.40 kg per 100 L) water in system.
- .2 **Sodium carbonate:** 0.9 lbs per 26.5 gallons (0.40 kg per 100 L) water in system.
- .3 **Low-foaming detergent:** 0.2 lbs per 26.5 gallons (0.01 kg per 100 L) water in system.

PART 3 - EXECUTION

3.1 Manufacturer's Instructions

- .1 **Compliance:** comply with manufacturer's written recommendations or specifications, including product technical bulletins, handling, storage and installation instructions, and datasheet.

3.2 Cleaning Hydronic Systems

- .1 **Timing:** systems operational, hydrostatically tested and with safety devices functional, before cleaning is carried out.
- .2 Cleaning Agency:
 - .1 Retain the following water treatment specialists to perform system cleaning and water treatment:
 - .1 PMC (contact: John Quish 1-800-668-0946)
- .3 Install instrumentation such as flow meters, orifice plates, pitot tubes, flow metering valves only after cleaning is certified as complete by water treatment specialist.
- .4 Cleaning procedures:
 - .1 Provide detailed report outlining proposed cleaning procedures at least 4 weeks prior to proposed starting date. Report to include:
 - .1 Cleaning procedures, flow rates, elapsed time.
 - .2 Chemicals and concentrations used.
 - .3 Inhibitors and concentrations.
 - .4 Specific requirements for completion of work.
 - .5 Special precautions for protecting piping system materials and components.
 - .6 Complete analysis of water used to ensure water will not damage systems or equipment.
- .5 Conditions at time of cleaning of systems:
 - .1 Systems: free from construction debris, dirt and other foreign material.
 - .2 Control valves: operational, fully open to ensure that terminal units can be cleaned properly.
 - .3 Strainers: clean prior to initial fill.
 - .4 Install temporary filters on pumps not equipped with permanent filters.
 - .5 Install pressure gauges on strainers to detect plugging.
- .6 **Report on Completion of Cleaning:** When cleaning is completed, submit report, complete with certificate of compliance with specifications of cleaning component supplier.
- .7 Hydronic Systems:
 - .1 Fill system with water, ensure air is vented from system.
 - .2 Fill expansion tanks 1/3 to 1/2 full, charge system with compressed air to at least 5 psi (35 kPa) (does not apply to diaphragm type expansion tanks).
 - .3 Use water metre to record volume of water in system to +/- 0.5%.
 - .4 Add chemicals under direct supervision of chemical treatment supplier.

- .5 Closed loop systems: circulate system cleaner at 140 degrees F (60 degrees C) for at least 36 hours. Drain as quickly as possible. Refill with water and inhibitors. Test concentrations and adjust to recommended levels.
- .6 Flush velocity in system mains and branches to ensure removal of debris. System pumps may be used for circulating cleaning solution provided that velocities are adequate.
- .7 Add chemical solution to system.
- .8 Establish circulation, raise temperature slowly to maximum design 180 degrees F (82 degrees C) minimum. Circulate for 12 hours, ensuring flow in all circuits. Remove heat, continue to circulate until temperature is below 100 degrees F (38 degrees C). Drain as quickly as possible. Refill with clean water. Circulate for 6 hours at design temperature. Drain and repeat procedures specified above. Flush through low point drains in system. Refill with clean water adding to sodium sulphite (test for residual sulphite).

3.3 Start-Up of Hydronic Systems

- .1 After cleaning is completed and system is filled:
 - .1 Establish circulation and expansion tank level, set pressure controls.
 - .2 Ensure air is removed.
 - .3 Check pumps to be free from air, debris, possibility of cavitation when system is at design temperature.
 - .4 Dismantle system pumps used for cleaning, inspect, replace worn parts, install new gaskets and new set of seals.
 - .5 Clean out strainers repeatedly until system is clean.
 - .6 Commission water treatment systems as specified in Section 23 25 00 - HVAC Water Treatment.
 - .7 Check water level in expansion tank with cold water with circulating pumps OFF and again with pumps ON.
 - .8 Repeat with water at design temperature.
 - .9 Check pressurization to ensure proper operation and to prevent water hammer, flashing, cavitation. Eliminate water hammer and other noises.
 - .10 Bring system up to design temperature and pressure slowly over a 48 hour period.
 - .11 Perform TAB as specified in Section 23 05 93 - Testing, Adjusting and Balancing for HVAC.
 - .12 Adjust pipe supports, hangers, springs as necessary.
 - .13 Monitor pipe movement, performance of expansion joints, loops, guides, anchors.
 - .14 If sliding type expansion joints bind or if bellows type expansion joints flex incorrectly, shut down system, re-align, repeat start-up procedures.
 - .15 Re-tighten bolts using torque wrench, to compensate for heat-caused relaxation. Repeat several times during commissioning.
 - .16 Check operation of drain valves.
 - .17 Adjust valve stem packings as systems settle down.
 - .18 Fully open balancing valves (except those that are factory-set).

- .19 Check operation of over-temperature protection devices on circulating pumps.
- .20 Adjust alignment of piping at pumps to ensure flexibility, adequacy of pipe movement, absence of noise or vibration transmission.

3.4 Cleaning

- .1 Proceed in accordance with Section 01 74 00 - Cleaning.
- .2 Upon completion and verification of performance of installation, remove surplus materials, excess materials, rubbish, tools and equipment.

END OF SECTION

PART 1 - GENERAL

1.1 Submittals

- .1 **Shop Drawings/Product Data:** Submit shop drawings/product data sheets for all products specified in this Section except piping and unions.

PART 2 - PRODUCTS

2.1 Pipe, Fittings and Joints

- .1 **Black Steel - Screwed Joint:** 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 **Black Steel - Welded Joint:** Mild black carbon steel, Grade B, ASTM A53, mill or site bevelled, complete with factory made seamless carbon steel butt welding fittings to ASTM A234, Grade WPB, with long sweep pattern elbows unless otherwise specified, and welded joints.
- .3 **Black Steel - Grooved End Mechanical Joint:** Mild black carbon steel, Grade B, ASTM A53, factory or site roll grooved, complete with Victaulic cast ductile iron grooved end fittings, including full flow elbows, conforming to ASTM A536, and Victaulic Style 107 "QuickVic" rigid couplings for sizes 50 mm (2") to 200 mm (8"), Victaulic Style 07 "Zero-Flex" rigid couplings for sizes 250 mm (10") to 300 mm (12"), Victaulic Style W07 AGS rigid couplings for sizes 350 mm (14") to 1525 mm (60").
- .4 **Soft Copper Pipe:** Type "L" seamless soft copper to ASTM B77.
- .5 **Hard Copper - Solder Joint:** 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:** Type "L" hard drawn seamless copper to ASTM B88, complete with Rigid Tool Co. "ProPress with Smart Connect feature" system copper fittings with EDPM seals, and pressure type crimped joints made by use of a Rigid Tool Co. Model RP 330 or Model RP 210 electro-hydraulic crimping tool.
- .7 **Polyvinyl Chloride (PVC) pipe and fittings:** IPEX Schedule 80 pipe to ASTM D1784 Type 1, Grade 1, and ASTM D1785 and CSA B137.3, maximum operating temperature at 60C (140F) and pressure at 1000 kPa (145 psig). Pipe joints and fittings to be solvent welding socket fittings to ASTM D2467 and raised face flanges with flange bolts and nuts to ANSI B16.1 and flanged gaskets to ANSI B16.21 of neoprene 3mm thick. Pipe joint cold solvent to ASTM 2564. Elbows and tees wall thickness not less than that of pipe with which they are used, socket weld type, moulded to ASTM D2467 for NPS 8 and under; fabricated fiberglass reinforced to CGSB 41-22 and CSA B137.3 for NPS 10 and over.
- .8 **High Density Polyethylene (HDPE) Piping:**

- .1 HDPE DIPS pipe manufactured from a PE 4710 resin that meets ASTM D3350 standard Specifications for Polyethylene Plastics Pipe and Fitting Materials. Pressure, with a minimum cell classification of 445574C. Pipe shall be manufactured to the dimensions of ASTM F714. Pipe thickness shall be DIPS DR 17 and shall have a min pressure rating of 125 psi.
- .2 Fabricated HDPE Polyethylene fittings shall have a pressure rating equal or greater than the pressure rating as the pipe; a DR less than the pipe shall be used. All fittings to be DIPS DR 17. Fittings shall be factory milled to allow for fusion to DIPS DR17 pipe. Fabricated fittings are to be manufactured using a Data Logger to record temperature, fusion pressure, and a graphic representation of the fusion cycle shall be part of the Quality Control records. Fittings shall be minimum 5 segment.
- .3 Butt Fusion Fittings- Fittings shall be made from HDPE pipe resin meeting ASTM D 3350 with a minimum cell classification of 445574C. Moulded butt fusion fittings shall have a manufacturing standard of ASTM D 3261. Fittings shall be minimum 5 segment. All fittings to be DIPS DR 17. Fittings shall be factory milled to allow for fusion to DIPS DR17 pipe.
- .4 Electrofusion Fittings - Fittings shall be made from resin or pipe meeting ASTM D 3350 with a minimum cell classification of 445574C. Electrofusion Fittings shall meet the manufacturing standard of ASTM F 1055. Fittings shall have the same pressure rating as the pipe or higher unless otherwise specified on the plans. All fittings to be DIPS DR 17. Fittings shall be factory milled to allow for fusion to DIPS DR17 1 pipe
- .5 Flanged and Mechanical Joint Adapters - Flanged and Mechanical Joint Adapters shall be made from materials containing resin that meets ASTM D 3350 with a minimum cell classification of 445574C. Fittings shall have the same pressure rating as the pipe or higher unless otherwise specified on the plans. All fittings to be DIPS DR 17. Fittings shall be factory milled to allow for fusion to DIPS DR17 pipe
- .6 Back Up Rings - Standard back-up rings to be convoluted ductile iron with AWWA C207 150 lb drilling pattern. Rings to have the same pressure rating as the pipe or higher unless otherwise specified on the plans. Provide anode and cathodic protection.
- .7 HDPE x Steel Butt Weld Transition Fittings – To be manufactured of Carbon Steel A53 grade and incorporated with the transition of manufactured of PE4710 (PE445574C) pipe. All pipe meets ASTM 3350 and ASTM 2513. Transition joint to meet or exceed the requirements of ASTM D2513 Category 1 Epoxy coated. HDPE fitting shall have the same pressure rating of the pipe, adjust DR rating as required. All fittings to be DIPS DR 17. Fittings shall be factory milled to allow for fusion to DIPS DR17 pipe
- .8 Fittings shall be as supplied by ISCO Industries, LLC or equivalent.

2.2 Piping Unions

- .1 **Screwed Piping:** 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:** 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:** 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. Acceptable products are:
 - .1 Toyo Valve Co. Fig. 5044A;
 - .2 Watts Industries (Canada) Inc. #FBV-3;
 - .3 Kitz Corp. Code 58;
 - .4 Victaulic Co. of Canada Ltd. Series 722;
 - .5 Apollo Valve #77-100.
- .2 **Butterfly Type:** 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 the valve closed and either side of the connecting piping removed. 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;
 - .7 Bray Valve and Controls Canada Series 31H.

2.4 Swing Check Valves

- .1 **Bronze - Screwed:** 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. Acceptable products are:
 - .1 Toyo Valve Co. Fig. 238;
 - .2 Nibco #T-433;
 - .3 Kitz Corp. Code No. 29.

- .2 **Steel - Grooved Ends:** 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:** 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. Acceptable products are:
 - .1 Toyo Valve Co. Fig. 435A;
 - .2 Watts Industries (Canada) Inc. #F-511;
 - .3 Kitz Corp. Code No. 78;
 - .4 Rite model number 210 CBT.

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. 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. 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. 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. Acceptable products are:
 - .1 Victaulic Co. of Canada Ltd. (Tour & Andersson) Series 787 screwed, Series 788 flanged, and 789 grooved end, and Series 78K "Koil Kit" valves.
 - .2 Armstrong Fluid Technology Series "CBVI" screwed or "CBVII" flanged;

2.9 Differential Pressure Control Valves

- .1 Differential pressure controllers used in conjunction with balancing valves to stabilize differential pressure across loads, equal to:
 - .1 2" (DN50) and Smaller Sizes:
 - .1 Tour & Andersson Series 793 STAP, 300 psi (2065 kPa), y-pattern, globe type with threaded ends, non-ferrous Ametal® brass copper alloy body and cone, EPDM o-ring seals, HNBR membrane and stainless steel spring, adjustable setpoint, shut off function and connections for portable differential meter.
 - .2 Sizes 2-1/2" (DN65) through 4" (DN100):
 - .1 Tour & Andersson Series 794 STAP, 300 psi (2065 kPa), y-pattern, globe type with flanged ends, ASTM A536 ductile iron body, all other metal parts and cone of Ametal® brass copper alloy, EPDM o-ring seals, HNBR membrane and stainless steel spring, adjustable set point, shut off function and connections for portable differential meter.

2.10 Radiator Shut-Off and Balancing Valves

- .1 Heavy pattern, straight, 1750 kPa (250 psi) rated at 120°C (250°F) bronze radiator valves, each complete with composition disc, spring loaded packing, and union. Inlet valves are to be equipped with a handle for shut-off. Outlet valves are to be equipped with a lockshield for shut-off and balancing. Acceptable products are:
 - .1 Dahl Brothers Canada Ltd. #11042 and #13013;
 - .2 Spirax Sarco Ltd. Type R.

PART 3 - EXECUTION

3.1 Demolition

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

3.2 Piping Installation Requirements

- .1 Provide all required hydronic piping. Pipe, unless otherwise specified, is to be:

-
- .1 for pipe to and including 65 mm (2½") diameter, Schedule 40 black steel, screwed, or type "L" hard copper with solder joints or pressure coupled joints;
 - .2 for pipe 50 mm (2") to 300 mm (12") diameter and larger, Standard weight black steel (10 mm/0.375" thickness) with grooved ends and Victaulic fittings and couplings, or, Standard weight black steel (10 mm/0.375" thickness) with welding fittings and welded joints;
 - .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.
 - .4 For high Density Polyethylene (HDPE) pipe follow the requirements of:
 - .1 ASTM F 2164 Standard Practice for Field leak testing of Polyethylene (PE) Pressure Pipe Systems using Hydrostatic pressure;
 - .2 ASTM F 2620 Standard Practice for Heat Fusion of Polyethylene Pipe and Fittings.
 - .5 Fusion of Polyethylene Pipe
 - .1 Sections of polyethylene pipe should be joined into continuous lengths on the jobsite above ground. The joining method shall be the butt fusion method and shall be performed in strict accordance with the pipe supplier's recommendations. The butt fusion equipment used in the joining procedures should be capable of meeting all conditions recommended by the pipe supplier. The butt fusion joining will produce a joint with weld strength equal to or greater than the tensile strength of the pipe itself. All field welds shall be made with fusion equipment equipped with a Data Logger. Temperature, fusion pressure and a graphic representation of the fusion cycle shall be part of the Quality Control records.
 - .2 Mechanical joining will be used where the butt fusion method cannot be used. Mechanical joining will be accomplished by using a HDPE flange adapter with a ductile iron back-up ring. Provide cathodic protection for all backer rings.
 - .3 Hot gas fusion, threading, solvents, and epoxies will not be used to join HDPE pipe.
 - .6 Inspection of Polyethylene Pipe
 - .1 Inspect the pipe for defects before installation and fusion. Defective, damaged or unsound pipe will be rejected.
 - .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. Refer to drawing control diagrams and details.

-
- .4 Connect equipment provided as part of the work of other Sections of the Specification with piping as indicated and/or required. Refer to pipe connection details on drawings.
 - .5 Where steel piping is required to be buried, apply two coats of Densopaste (Denso of Canada Ltd.) primer to all buried surfaces after assembly and testing. Hot or cold applied tape as manufactured by Tapecoat, selected for the application and applied to manufacturer's instructions, is also acceptable.
 - .6 **Unions:** 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 all 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 the drawings.
 - .7 **Shut-off Valves:** 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 the drawings. Valves in piping to and including 50 mm (2") diameter are to be ball type. All other shut-off valves are to be ball or butterfly type unless otherwise specified. Locate all valves so that they are easily accessible. Wherever possible, install valves at uniform height. Provide chain operators for valves which are inaccessible for operation from floor level.
 - .8 **Check Valves:** Provide a check valve in the discharge piping of every pump, and elsewhere in piping where shown on the drawings. Where check valves are required in vertical piping, ensure that they are suitable in all respects for the application. Note that check valves for vertical in-line and/or base mounted circulating pumps are integral with the discharge accessory.
 - .9 **Drain Valves:** Provide a drain valve at the base of each piping riser, in drain connections to equipment, in low points of horizontal piping, and wherever else shown and/or specified.
 - .10 **Circuit Balancing Valves:** Provide circuit balancing valves in piping generally where shown on the drawings but with exact locations in accordance with instructions of personnel doing system flow balancing work. Confirm locations prior to installation. Balancing valves to be sized according to design flow. Ensure that balancing valves are a minimum of 10 pipe diameters downstream of any pump, 5 pipe diameters downstream of any or fitting and a minimum of 2 pipe diameters upstream of any fitting.
 - .11 **Differential Pressure Control Valves:** Provide as indicated on drawings and schematics. Mechanical contractor shall consult with balancing valve manufacturer to ensure correct valve selection and installation in accordance with manufacturer's recommendation.
 - .12 **Grooved Piping Systems:** Install grooved joints in accordance with Victaulic's latest published installation instructions. Ensure grooved ends are clean, free from indentations, projections, and roll marks in the area from pipe end to groove. Select gaskets with an elastomer grade suitable for the intended service and produced by the coupling manufacturer. Provide on-site training in the use of grooving tools and installation of grooved joint products for field personnel from grooved coupling manufacturer's factory trained representative. All grooved products to be from a single manufacturer

3.3 Flushing and Cleaning Piping

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

3.4 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 the mechanical work Section entitled Testing, Adjusting, and Balancing.

END OF SECTION

PART 1 - GENERAL

1.1 Submittals

- .1 **Shop Drawings/Product Data:** Submit shop drawings/product data sheets for all products specified in this Section except piping and unions. Ensure that shop drawings and product data sheets confirm that products proposed meet all requirements of the Contract Documents.

1.2 Quality Assurance

- .1 **Canadian Registration Number:** All valves and similar items for use in systems with a pressure rating of 105 kPa (15 psi) is to be stamped with a Canadian Registration Number (CRN).
- .2 **Codes and Standards:** All steam and condensate piping system work is to be in accordance with the following:
 - .1 CSA B51, Boiler, Pressure Vessel, and Pressure Piping Code;
 - .2 ASME B31, Standards of Pressure Piping;
 - .3 and governing Provincial and/or Municipal Codes and Regulations.

PART 2 - PRODUCTS

2.1 Pipe, Fittings and Joints

- .1 **Black Steel - Screwed Joint:** Mild black carbon steel, Grade B, ASTM A53, complete with Class 125 or Class 250 cast iron threaded fittings to ANSI/ASME B16.4, and screwed joints.
- .2 **Black Steel - Welded Joint:** Mild black carbon steel, Grade B, ASTM A53, mill or site bevelled, complete with factory made seamless carbon steel butt welding fittings to ASTM A234, Grade WPB with a wall thickness to match the pipe, and welded joints.

2.2 Piping Unions

- .1 **Screwed Low Pressure Steam Piping:** Malleable iron, ground joint, 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 **Screwed Condensate Piping:** Malleable iron, ground joint, factory tested screwed unions and union elbows with a brass to iron seat and a minimum pressure rating of 4140 kPa (600 psi) WOG (non-shock).
- .3 **Screwed High Pressure Steam Piping:** Screwed unions as specified above for screwed condensate piping.
- .4 **Welded Low Pressure Steam Piping:** Forged carbon steel slip-on raised face welding flange unions to ASTM A105, 150 lb. Class.
- .5 **Welded Condensate Piping:** Welding flange unions as specified above for welded low pressure steam piping but 300 lb. Class.

- .6 **Welded High Pressure Steam Piping:** 300 lb. Class welding flange unions as specified for welded condensate piping.
- .7 **Boiler Feedwater Piping:** As specified above for low pressure steam piping.

2.3 Shut-Off Valves

- .1 **Low Pressure Steam and Condensate:** Ball, gate or globe type valves suitable in all respects for steam and condensate service, and as follows:
 - .1 **ball type to 50 mm (2"):** forged brass or bronze full bore ball valve, 1035 kPa (150 psi) WSP rated, complete with a chrome plated forged brass ball, PTFE seat and gland packing, screwed ends and a carbon steel handle - acceptable products are:
 - .1 Kitz Corp. Code No. 58;
 - .2 Watts Industries (Canada) Inc. #FBV-3;
 - .3 Toyo Valve Co. Fig. 5044A;
 - .4 Apollo Valve # 77-100;
 - .5 Nibco #T-FP-600, or #T-585-70.
 - .2 **ball type 65 mm (2½") and larger:** cast iron, flanged, 860 kPa (125 psi) WSP rated ball valve with a cast iron Teflon fused ball, blow-out proof stainless steel stem, reinforced Teflon seats, and steel handle which is lockable in fully open and fully closed positions - acceptable products are:
 - .1 American Valve, Inc. 4000 Series;
 - .2 Nibco #F-510-CS-R-25, or #F-510-CS-R-66-FS.
 - .3 **bronze gate to 50 mm (2"):** cast bronze, screwed, 860 kPa (125 psi) WSP rated rising stem gate valve with a screwed-in cast bronze bonnet, cast bronze disc, and zinc or aluminum die-cast handwheel - acceptable products are:
 - .1 Kitz Corp. Code No. 24;
 - .2 Nibco #T-111;
 - .3 Toyo Valve Co. Fig. 293;
 - .4 Watts Industries (Canada) Inc. #B31 00.
 - .4 **bronze globe to 50 mm (2"):** cast bronze, screwed, 860 kPa (125 psi) WSP rated rising stem globe valve with a union bonnet, reinforced PTFE disc, and zinc or aluminum die-cast handwheel - acceptable products are:
 - .1 Kitz Corp. Code. No. 03;
 - .2 Nibco #T-235-Y;
 - .3 Toyo Valve Co. Fig. 220;
 - .4 Watts Industries (Canada) Inc. #B4000.

-
- .5 **cast iron gate 65 mm (2.5") and larger:** Class 125 cast iron bronze mounted rising stem flanged gate valves, each equipped with a cast iron disc and a cast or ductile iron handwheel - acceptable products are:
 - .1 Kitz Corp. Co. No. 72;
 - .2 Nibco #F-617-0;
 - .3 Toyo Valve Co. Fig. 421A;
 - .4 Watts Industries (Canada) Inc. #F-503.
 - .6 **cast iron globe 65 mm (2.5") and larger:** Class 125 cast iron bronze fitted flanged globe valves, each equipped with a cast iron disc and a cast or ductile iron handwheel - acceptable products are:
 - .1 Kitz Corp. Code No. 76;
 - .2 Nibco #F-718-B;
 - .3 Toyo Valve Co. Fig. 400A;
 - .4 Watts Industries (Canada) Inc. #F-503.
 - .2 **High Pressure Steam and Condensate:** Gate or globe type valves suitable in all respect for steam and condensate service, and as follows:
 - .1 **bronze gate to 50 mm (2"):** Class 150 cast bronze gate valves, each equipped with screwed ends, rising stem, cast bronze disc, and cast zinc, or aluminum handwheel - acceptable products are:
 - .1 Kitz Corp. Code No. 42;
 - .2 Nibco #T-134;
 - .3 Toyo Valve Co. Fig. 298;
 - .4 Watts Industries (Canada) Inc. #B-3110.
 - .2 **bronze globe to 50 mm (2"):** Class 150 cast bronze globe valves, each equipped with screwed ends, rising stem, non-metallic disc, and cast zinc or aluminum handwheel - acceptable products are:
 - .1 Kitz Corp. Code No. 09;
 - .2 Nibco #T-235-Y;
 - .3 Toyo Valve Co. Fig. 221;
 - .4 Watts Industries (Canada) Inc. #B-4000.
 - .3 **cast steel gate 65 mm (2½") and larger:** Class 150 OS & Y, rising stem, bolted bonnet cast steel gate valve with plain solid wedge or flexible solid wedge depending on valve size, flanged ends, and ductile iron handwheel - acceptable products are:
 - .1 Kitz Corp. Fig. 150 SCLS;
 - .2 Bonney Forge Corp. Fig. 1-11-RF;
 - .3 BERIC Fig. 101-RF-AA08-H.

- .4 **cast steel globe 65 mm (2½") and larger:** Class 150 OS&Y, rising stem, bolted bonnet cast steel globe valve with swivel disc, flanged ends, and ductile iron handwheel - acceptable products are:

- .1 Kitz Corp. Fig. 150 SCJS;
- .2 Bonney Forge Corp. 1-31-RF;
- .3 BERIC Fig. 201-RF-EA08-H.

- .3 **Boiler Feedwater:** As specified above for low pressure steam piping.

2.4 Swing Check Valves

- .1 **Low Pressure Steam & Condensate:** Horizontal swing check valves as follows:

- .1 **bronze to 50 mm (2"):** Class 125 "Y" pattern screwed cast bronze swing check valve - acceptable products are:

- .1 Kitz Corp. Code No. 22;
- .2 Nibco #TE-413-B;
- .3 Toyo Valve Co. Fig. 236;
- .4 Watts Industries (Canada) Inc. #B-5000.

- .2 **cast iron check 65 mm (2½") and larger:** Class 125 cast iron bronze trim swing check valve with flanged ends and bolted cover - acceptable products are:

- .1 Kitz Corp. Code No. 78;
- .2 Nibco #FE-918-B;
- .3 Toyo Valve Co. Fig. 435A;
- .4 Watts Industries (Canada) Inc. #F-511.

- .2 **High Pressure Steam & Condensate:** Horizontal swing check valves as follows:

- .1 **bronze to 50 mm (2"):** Class 300 cast bronze "Y" pattern swing check valve with screwed ends - acceptable products are:

- .1 Kitz Corp. Code No. 19;
- .2 Nibco #T-473;
- .3 Toyo Valve Co. Fig. 360;
- .4 Watts Industries (Canada) Inc. #B-5030.

- .2 **cast steel 65 mm (2½") and larger:** Class 300 cast steel swing check valves, each complete with flanged ends - acceptable products are:

- .1 Kitz Corp. Fig. 300SCOS;
- .2 Bonney Forge Corp. 3-61-RF;
- .3 BERIC Fig. 303-RF-EA08-X.

- .3 **Boiler Feedwater:** As specified for low pressure steam piping

2.5 Drain Valves

- .1 Minimum 1725 kPa (250 psi) water rated, 20 mm ($\frac{3}{4}$ ") diameter straight pattern bronze or brass ball valves, each complete with a stainless steel ball and stem, threaded outlet suitable for coupling connection of 20 mm ($\frac{3}{4}$ ") hose, locking handle, and a cap and chain. Acceptable products are:
 - .1 Toyo Valve Co. Ltd. Fig 5046;
 - .2 Nibco #T-585-70-HC;
 - .3 Kitz Corp. Code No. 68AC;
 - .4 Apollo Valve # 70-140-64;
 - .5 Watts Industries (Canada) Inc. #B-6000-CC.

PART 3 - EXECUTION

3.1 Demolition

- .1 Do all required steam and condensate piping demolition/revision work. Refer to demolition requirements specified in the mechanical work Section entitled Demolition and Revision Work.

3.2 Steam and Condensate Piping Installation Requirements

- .1 Provide all required steam and condensate piping.
- .2 Do all piping work with working pressures above 105 kPa (15 psi) in accordance with requirements of CSA B51 and ASME B31.
- .3 Piping, unless otherwise specified, is to be mild black steel, screwed for pipe to and including 50 mm (2") diameter, screwed or welded for pipe 65 mm (2½") diameter and larger, and as follows:
 - .1 **low pressure steam – screwed:** Schedule 40, complete with Class 125 screwed fittings;
 - .2 **high pressure steam – screwed:** Schedule 40, complete with Class 250 screwed fittings;
 - .3 **condensate, all pressures – screwed:** Schedule 80, complete with Class 250 screwed fittings;
 - .4 **low pressure steam – welded:** Schedule 40 with butt weld fittings;
 - .5 **high pressure steam – welded:** Schedule 40 with butt weld fittings;
 - .6 **condensate, all pressures welded:** Schedule 80 with butt weld fittings.
- .4 Unless otherwise specified, slope horizontal steam mains down 25 mm (1") in 6 m (20') in the direction of flow. Steam mains may be run level if frequently and adequately dripped with equal tee connections and trapped at and through riser connections, however, slope such steam mains, if no branches are connected thereto for more than 7.5 m (25'), 25 mm (1") in a 6 m (20') as specified above. Provide equal tee drip stations every 36 m (120') to 45 m (150") in steam mains greater than 100 mm (4") diameter.

- .5 Unless otherwise approved, slope horizontal condensate return mains 65 mm (2½") diameter and larger 25 mm (1") in 6 m (20'). Slope smaller condensate return lines and condensate drip piping not less than 25 mm (1") in 3 m (10'). Slope all condensate piping in the direction of flow.
- .6 Slope steam supply and condensate return branch connections to and from equipment a minimum of 25 mm (1") in 1.8 m (6'), the slope being downward to the risers to which the branch piping connects. Increase this slope wherever necessary to prevent trapping due to expansion of the risers, or provide steam drip trap assemblies.
- .7 Extend branch steam supply piping off the top of horizontal mains, either 90° vertically or at a 45° angle, as space permits.
- .8 Make all changes in pipe size in horizontal steam and condensate piping with eccentric fittings flush with the pipe on the bottom. Do not use bushings in any piping.
- .9 Install automatic control valves, piping wells and similar piping and/or equipment mounted control components required for automatic temperature control systems and supplied as part of the control work. Refer to drawing control diagrams and details.
- .10 Connect air handling system steam heating coils with steam and condensate piping in accordance with requirements of the drawing detail.
- .11 Include for all required steam and condensate piping and accessories for connections to the Owner's equipment as shown and/or scheduled.
- .12 Connect new air handling unit steam humidifiers with steam and condensate piping.

3.3 Boiler Feedwater Piping Installation Requirements

- .1 Provide all required boiler feedwater piping.
- .2 Pipe, unless otherwise specified, is to be Schedule 40 black steel, screwed with Class 125 fittings, or welded with butt weld fittings and slip-on flanges as required.
- .3 Slope all piping so that it can be completely drained.

3.4 Installation of Unions

- .1 Provide screwed unions or weld-on flange joint unions in all piping connections to valves, strainers and similar piping system components which may need maintenance or repair, at all equipment connections, in long runs of piping exceeding 9 m (30') at 4.5 m (15') intervals to permit removal of sections of piping, and wherever else indicated on the drawings.

3.5 Installation of Shut-Off Valves

- .1 Refer to Part 3 of the mechanical work Section entitled Basic Mechanical Materials and Methods.
- .2 **Low Pressure Steam & Condensate:** Valves in piping where a throttling or balancing action is required are to be globe type. All other valves are to be ball or gate type.
- .3 **High Pressure Steam & Condensate:** Valves in piping where a throttling or balancing action is required are to be globe type. All other valves are to be gate type.
- .4 **Boiler Feedwater:** As for low pressure steam piping.

3.6 Installation of Check Valves

- .1 Provide a check valve in the discharge piping of each pump whether shown on the drawings or not, and wherever else shown and/or specified on the drawings.

3.7 Installation of Drain Valves

- .1 Provide a drain valve at the base of each piping riser, in drain connections to equipment, and wherever else shown and/or specified. At the bottom of risers provide minimum 200 mm (8") long, minimum 25 mm (1") diameter capped dirt pockets with drain valves.

3.8 Flushing and Cleaning Piping

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

3.9 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 the mechanical work Section entitled Testing, Adjusting, and Balancing.

END OF SECTION

PART 1 - GENERAL

1.1 Submittals

- .1 **Shop Drawings/Product Data:** Submit shop drawings/product data sheets for all products specified in this Section. Shop drawings/product data sheets must confirm that the products proposed meet all requirements of the Contract Documents.
- .2 **Piping Anchor Shop Drawings:** Shop drawings for piping anchors must be prepared and stamped by a professional Structural Engineer registered in the jurisdiction of the work including detailed stress calculations. Refer to requirements for Contractor retained engineers specified in the mechanical work Section entitled Mechanical Work General Requirements.
- .3 **Letter of Pipe Anchor Certification:** Submit a letter from the pipe anchor design engineer to state that the engineer has visited the site to examine the installation of the pipe anchors and that the pipe anchor installation is in accordance with the reviewed anchor shop drawing.
- .4 **Steam Drip Trap Tester:** Submit a hand-held steam drip trap tester as specified in Part 3 of this Section.

1.2 Quality Assurance

- .1 **Canadian Registration Number:** All steam and condensate piping system specialties for use in systems with a pressure rating of above 105 kPa (15 psi) are to be stamped with a Canadian Registration Number (CRN).
- .2 **Codes and Standards:** All steam and condensate piping system specialties are to be in accordance with the following:
 - .1 CSA B51, Boiler, Pressure Vessel, and Pressure Piping Code;
 - .2 ASME B31, Standards of Pressure Piping;
 - .3 governing Provincial and/or Municipal Codes and Regulations.

PART 2 - PRODUCTS

2.1 Flexible Pipe Connections

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

2.2 Piping Expansion Joints

- .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, selected to suit the operating temperature plus 25% safety factor. Acceptable products are:
 - .1 Senior Flexonics Ltd. Series CSF "High-Corr";
 - .2 The Metraflex Co. Model MC.
- .2 Externally pressurized, 1380 kPa (200 psi) rated expansion joints with a stainless steel bellows and shroud, and welding or threaded steel nipple ends. Acceptable products are:
 - .1 Senior Flexonics Ltd. Series "H";
 - .2 The Metraflex Co. Model "HP".

2.3 Piping Alignment Guides

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

2.4 Pipe Anchors

- .1 Welded structural black steel anchors of a design, size, and type to securely anchor the pipe as shown and/or required as per engineered shop drawings prepared by the Contractor. Each anchor is to be designed and detailed by a professional structural engineer registered in the place of the work. Submit anchor design, fabrication, and installation shop drawings, stamped by the design engineer.

2.5 Steam Main Back Pressure Regulators

- .1 Cast iron, screwed or flanged back pressure regulators, pilot-actuated diaphragm-operated type with stainless steel trim, each sized to the boiler steam discharge pipe connection to the header. Acceptable products are:
 - .1 Spirax Sarco Canada Ltd. #25BP;
 - .2 Flowserve;
 - .3 Armstrong International Inc.

2.6 Steam Pressure Reducing Valves

- .1 Factory assembled and tested, self-contained, dead end shut-off, pilot operated pressure reducing valves as per the drawing schedule, screwed or flanged as required, each complete with a 1725 kPa (250 psi) rated cast iron valve and pilot body with stainless steel trim, stainless steel valve diaphragm, and phosphor bronze pilot diaphragm. Acceptable manufacturers are:

- .1 Spirax Sarco Canada Ltd. Model 25P;
- .2 Armstrong International Ltd..
- .3 Singer Valve Co. Ltd.;
- .4 Kieley & Mueller.

2.7 Steam Pressure Control Valves

- .1 Electrically-actuated steam pressure reducing valves are to have components as follows:
 - .1 a factory assembled and tested, modulating, single-seat, two-port, globe-style steam pressure control valve with equal percentage characteristics, NPT or ANSI 125/250 flange rated, leakage rate equal to ANSI class VI bubble-tight shut-off using high temperature PEEK seat, and each complete with a cast iron valve body with stainless steel trim, and a drop-in seat for ease of valve trim removal;
 - .2 a fast-acting electronic actuator with valve closing rate of not less than 1.7 mm/second for fast response, complete with a positioner function, a minimum thrust of 4.5 kN, an ambient operating temperature operating limit of -20°C to 60°C (-4°F to 140°F), reversible with linear output, powered by 24 VAC. Enclosure rating IP65 required. Materials are polycarbonate case and die-cast aluminium housing; Valve actuator must include super-capacitor to allow 100% fail-safe (open or closed position as desired) in the event of power failure; Fault indicator relay integral to the actuator shall be provided to communicate valve failure to the BMS;
 - .3 Valve noise levels shall not exceed 90 dB at one meter distance from the valve. When required, a low noise trim shall be employed. A valve utilizing noise trim shall meet valve duty requirements as specified
 - .4 a hand wheel to allow for manual opening and closing of valve;
 - .5 a multi-function process controller to control steam pressure, complete with a RS485 serial communication port at 9200 baud, Modbus/Jbus, two analog input signals for sensor input, BMS/PLC interface, two analog outputs, local/remote set point, output forcing, keyboard lock and four digital outputs for alarms, and an external supply of 24 VDC and main power supply of 100-240VAC, 50-60 Hz.
 - .6 an electronic pressure sensor and transmitter and sensor is to have a 2-wire 4-20 mA current loop with 1/4" NPT process connection;
 - .7 syphon tube and valve assemblies to be included.
- .2 Acceptable manufacturers are:
 - .1 Spirax Sarco Canada Ltd. Model "L" or "K" Series Mark 2 with Model AEL6 series SMART electronic actuator, Model SX77+ Controller, and Model EL2600 electronic pressure sensor and transmitter;
 - .2 Singer Valve Co. Ltd.;
 - .3 Armstrong International Ltd.

2.8 Steam Temperature Control Valves

-
- .1 Electrically-actuated steam temperature control valves are to have components as follows:
 - .1 A factory assembled and tested, modulating, single-seat, two-port, globe-style steam temperature control valve. Valve body to be cast iron or ductile iron with stainless steel trim, NPT or ANSI 125/250 flange rated. Valve leakage rate to be ANSI class IV. Control valve to have equal percentage characteristics. The valve shall complete with a drop-in seat for ease of removal of valve trim;
 - .2 A fast-acting SMART electric actuator with valve closing rate of not less than 1.7 mm/second to adequately respond to demand. Actuator is reversible with linear output. Actuator to be equipped with positioner function. Electric actuators powered by 24 Vac. Minimum thrust of 4.5 k-N required. Ambient operating temperature operating limits are -20degC to +60degC. Enclosure rating IP65 required. Materials are polycarbonate case and die-cast aluminium housing. Electrical super capacitor fail-safe option to be included.
 - .3 Valve noise levels shall not exceed 90 dB at one meter distance from the valve. When required, a low noise trim shall be employed. A valve utilizing noise trim shall meet valve duty requirements as specified
 - .4 Valve control by the Controls Contractor.
 - .5 Refer to Steam flow diagram drawing where applicable
 - .6 Acceptable manufacturers are:
 - .1 Spirax Sarco Canada Ltd. Model "L" or "K" Series Mark 2 with Model AEL6 series SMART electronic actuator;
 - .2 Singer Valve Co. Ltd.;
 - .3 Armstrong International Ltd.

2.9 Steam Separators

- .1 Cast iron baffle type steam separators, each sized to the steam pipe size, each complete with screwed or flanged ends as required and a thermodynamic steam trap module. Acceptable products are:
 - .1 Spirax Sarco Canada Ltd. Model S2 or Model S3;
 - .2 Flowserve;
 - .3 Armstrong International Inc.;
 - .4 Colton Industries.

2.10 Pressure Relief Valves

- .1 Factory tested, rated and certified, bronze or cast iron bronze fitted, 1725 kPa (250 psi) rated pressure relief valves, each factory tested, certified and sealed, and each capable of relieving the full output of the steam pressure reducing valve(s) located upstream. Acceptable products are:
 - .1 Spirax Sarco Canada Ltd. "SVI" Series;
 - .2 Dresser Industries;

- .3 ITT Bell & Gossett;
- .4 McDonnell & Miller;
- .5 Conbraco.

2.11 Drip Pan Elbows

- .1 Cast iron drip pan elbow sized to the discharge pipe size of the associated pressure relief valve, each complete with screwed or flanged connections as required, and a drain connection tapping. Acceptable products are:
 - .1 Spirax Sarco Canada Ltd. Type 299;
 - .2 Flowserve;
 - .3 Armstrong International Ltd.

2.12 Steam Vent Exhaust Heads

- .1 Stainless steel exhaust head, screwed or flanged as required, designed and constructed to eliminate oil, grease and water from the discharged steam while not interrupting or restricting steam flow. Acceptable products are:
 - .1 Spirax Sarco Canada Ltd. Model VH;
 - .2 Flowserve;
 - .3 Armstrong International Ltd.

2.13 Air Vents

- .1 **Low Pressure Steam:** Cast iron body float and thermostatic type air vent with stainless steel float, element and valve head, bronze valve seat, and nylon ball valve. Acceptable products are:
 - .1 Spirax Sarco Canada Ltd. Model 6A;
 - .2 Flowserve;
 - .3 Colton Industries.
- .2 **High Pressure Steam:** Brass alloy body and cap float type air vent with plastic float, rubber valve, and stainless steel valve seat and check valve. Acceptable products are:
 - .1 Spirax Sarco Canada Ltd. Model AE 30;
 - .2 Flowserve;
 - .3 Colton Industries.

2.14 Strainers

- .1 Cast iron wye shaped strainers, screwed or flanged as required, minimum 1035 kPa (150 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. Acceptable manufacturers are:
 - .1 Spirax Sarco Canada Ltd.;

- .2 Toyo Valve Co, Ltd.;
- .3 Armstrong International Ltd.;
- .4 Kitz Corp.;
- .5 Watts Industries (Canada) Inc.;
- .6 Mueller Steam Specialty Products;
- .7 Colton Industries.

2.15 Pump Trap

- .1 SG iron constructed, non-electronic automatic pump trap sized to suit the application, steam operated to 1380 kPa (200 psig), screwed or flanged as required, and complete with a swing type inlet check valve, an internal trap mechanism containing dual stainless steel floats connected with a two stage trap and an internal pump mechanism containing a stainless steel single tension spring snap-action device with no external seals or glands. Acceptable products are:
 - .1 Spirax Sarco Canada Ltd. Model APT14;
 - .2 Armstrong International Ltd.

2.16 Steam Drip Traps

- .1 Steam drip traps are to be selected to suit the inlet pipe size and inlet steam pressure, and are to be as follows:
 - .1 **thermodynamic traps:** maximum 4135 kPa (600 psi) rated, integral seat design stainless steel thermodynamic type traps, each complete with an integral strainer and insulating cover – acceptable products are:
 - .1 Spirax Sarco Canada Ltd. "TD" Series;
 - .2 Flowserve;
 - .3 Armstrong International Ltd.;
 - .4 Colton Industries.
 - .2 **float and thermostatic traps:** modulating discharge mechanical ball float type, each complete with a ductile or cast iron body, stainless steel trim, screwed or flanged ends as required, and an integral thermostatic air vent – acceptable products are:
 - .1 Spirax Sarco Canada Ltd "FT" Series;
 - .2 Flowserve;
 - .3 Armstrong International Ltd.;
 - .4 Colton Industries.
 - .3 **balanced pressure thermostatic traps:** angle, straightway or vertical pattern as required, each complete with a brass body and cap, brass union inlet nipple, stainless steel element assembly and stainless steel spring – acceptable products are:

- .1 Spirax Sarco Canada Ltd. types T-25, TB-25 and type "H";
- .2 Flowserve;
- .3 Armstrong International Ltd.;
- .4 Colton Industries.

2.17 Steam Drip Trap Testing Components

- .1 Spirax Sarco Canada Ltd. "SPIRA-tec" steam drip trap testing components as follows:
 - .1 **sensor chambers:** #ST 17 ductile iron or #ST 14 steel sensor chambers as required, each complete with a stainless steel sensor element, sensor plug gasket, and, except where connected to a remote test point, a removable stainless steel drain plug;
 - .2 **remote test points:** #R1 surface mounting single test point units, each complete with a #PT 2 plug tail assembly with a screw-on connection and brass housing;
 - .3 **remote multiple test points:** # R12 surface mounting twelve (12) point test unit with selector switch and #PT2 plug tail assemblies to suit the number of traps to be monitored;
 - .4 **indicator:** Type 30 hand held trap fault indicating unit complete with battery and indicator cable.
- .2 Acceptable manufacturers are:
 - .1 Spirax Sarco Canada Ltd.;
 - .2 Flowserve.

2.18 Steam Vacuum Breakers

- .1 Screwed brass body vacuum breakers, each complete with screw-in brass cap, and stainless steel valve and valve seat. Acceptable products are:
 - .1 Spirax Sarco Canada Ltd. Model VB14;
 - .2 Flowserve;
 - .3 Armstrong International;
 - .4 Colton Industries.

2.19 Flash Tanks

- .1 Factory made cylindrical flash tanks, each constructed of welded Schedule 40 seamless steel pipe with Schedule 40 seamless steel pipe caps for 1035 kPa (150 psi) steam service, each sized to the pipe size and load by the manufacturer, and each complete with a wear plate, Schedule 80 vent pipe connection flange, Schedule 160 threaded inlet connection, bottom drain coupling, mounting flange, an exterior coat of primer, correctly selected back pressure valve, safety valve, pressure gauge, and steam trap module. Acceptable products are:
 - .1 Spirax Sarco Canada Ltd. Model FV;
 - .2 Flowserve;

- .3 Armstrong International Inc.;
- .4 Clemmer Pressure Vessel;
- .5 Colton Industries.

2.20 Condensate Cooler and Flash Condensers

- .1 Factory fabricated flash condensers, each constructed of welded steel, each suitable for wall or floor mounting as required, and each complete with:
 - .1 a round type 304 stainless steel tank with mounting hardware;
 - .2 a sensor and union kit assembly in the cooled condensate outlet with capillary to the cold water inlet;
 - .3 a brass cold water inlet strainer, stainless steel check valve, and cold water spray nozzle with thermostatic control to permit a controlled volume of domestic cold water to quench the flash steam as well as sub-cool the condensate to maximum 65.5°C (150°F) before being dumped to drain.
- .2 Acceptable manufacturers are:
 - .1 Spirax Sarco Canada Ltd. JC200FCC;
 - .2 Flowserve;
 - .3 Armstrong International Inc.;
 - .4 Clemmer Technologies Inc.;
 - .5 Colton Industries.

2.21 Steam Flow Metering Equipment

- .1 Steam metering equipment, compatible in all respects with the building automation system, and as follows:
 - .1 **steam meter:** Spring loaded variable area type constructed of Type 316 stainless steel body, stainless steel internals and a Inconel X750 spring, and with a pressure and temperature rating to match flange rating with a maximum temperature of 400°C (750°F) and a minimum operating pressure of 0.6 bar g (9 psig), a turndown ratio of 100:1, a meter accuracy of $\pm 1\%$ of actual flow and a repeatability to exceed 0.25%, and a pressure drop of 498 m bar (200 inches water gauge) across the meter;
 - .2 **mass flow computer/transmitter:** Specifically configured for the corresponding flow meter through a Modbus IP equipped PC using manufacturer specified configuration software, the unit converts the differential and static pressures into the corrected mass flowrate and connects to building management system via a Modbus IP link and is complete with a cast aluminium enclosure, a Type 316 stainless steel body and Type 316 stainless steel 3-way manifold, an external power supply of 6-30 VDC to power the transmitter, an integral datalogger, and an LCD display to provide local indication of the following:
 - .1 steam temperature
 - .2 steam pressure

- .3 steam flow
 - .4 steam total
 - .5 steam energy rate
 - .6 steam energy total
 - .7 density compensated rate and total saturated steam flow.
- .2 Acceptable products/manufacturers are:
- .1 Spirax Sarco Canada Ltd. ILVA steam flow meter and a Scanner 2000 steam mass flow transmitter/computer;
 - .2 Flowserve;
 - .3 Armstrong International.

2.22 Pressure Powered Pump

- .1 Equal to Spirax Sarco Canada Ltd. Pivotrol Pump (patented) model PTC, non-electrical pressure powered pump, size 75 mm x 50 mm (3" x 2"), operated by steam, compressed air or other pressurized gas up to 1380 kPa (200 psig), and complete with ductile iron casing, stainless steel split disc check valves on inlet and outlet connections, Spirax Sarco PowerPivot (patented) technology inside casing, and an Inconel internal spring with a lifetime warranty.

2.23 Condensate Pump Set

- .1 Package type condensate pump set with receiver and control as per the drawing schedule, complete with:
 - .1 **pump(s):** vertical, centrifugal, bronze fitted with a one-piece cast iron casing column, discharge pipe and elbow, and motor stand, an enclosed, machined bronze, hydraulically balanced impeller secured to a renewable stainless steel pump shaft, external stuffing box not subjected to discharge pressure, a non-metallic water lubricated lower submerged shaft bearing, and a 3600 RPM vertical motor conforming to requirements specified in the mechanical work Section entitled Basic Mechanical Materials and Methods;
 - .2 **control:** for single pump packages, a control assembly consisting of a heavy-duty two-pole float switch actuated by a seamless copper float, all factory mounted and pre-wired;
 - .3 **control:** for duplex pump packages, a control assembly consisting of a heavy-duty two-pole float switch actuated by a seamless copper float for each pump, and an alternator to alternate the lead pump on each successive cycle, all factory mounted and pre-wired;
 - .4 high level alarm switch: McDonnell & Miller, Flow Tech Corp. "Flotect" or equal float actuated automatic reset alarm switch, minimum 690 kPa (100 psi) and 120°C (250°F) rated, capable of transmitting an alarm signal to an alarm device or a building management system;

- .5 receiver: a cast iron or steel (depending on receiver capacity) condensate receiver with integral support legs for securement to a concrete pad, screwed type pipe connection and float switch tappings, and, for single pump tanks, a second blank flanged opening for a second future pump.
- .2 Acceptable manufacturers are:
 - .1 Armstrong International Ltd.;
 - .2 Spirax Sarco Canada Ltd.;
 - .3 G.S. Dunham "MEPCO";
 - .4 Shipco Pumps.

2.24 Pressure Powered Duplex Condensate Pump Sets

- .1 Spirax Sarco, Canada Ltd. Model PPC packaged, pressure powered, skid mounted, non-electric duplex condensate pump set with receiver as specified on the drawings, each constructed for a pressure of 1035 kPa (150 psi). Each assembly is to be complete with:
 - .1 a formed or welded skid type base;
 - .2 a vented, horizontal, steel pipe mounted, 225 L (50 gal) capacity welded steel condensate receiver with bolted hand-hole cleanout, drain plug, gauge glass set with valves, and high condensate level alarm with auxiliary contact;
 - .3 two 75 mm x 50 mm (3" x 2") cast iron body pumps, each complete with a bolted access cover, float operated snap-acting mechanism which operates a pilot valve and 2-way steam valve to provide pressure to operate the pump, and loose removable insulating cover;
 - .4 screwed steel piping to connect the pumps and receiver complete with bronze inlet and outlet check valves.
- .2 Acceptable manufacturers are:
 - .1 Spirax Sarco Canada Ltd.;
 - .2 Flowserve;
 - .3 Armstrong International.

PART 3 - EXECUTION

3.1 Installation of Flexible Piping Connections

- .1 Install flexible connections in accordance with the manufacturer's instructions.

3.2 Installation of Expansion Compensators And Pipe Guides

- .1 Provide expansion compensation in piping where shown on the drawings as shown and/or as required withstand all anticipated static and dynamic loading conditions which may act upon the mechanical piping system. Install in accordance with the manufacturer's instructions. Secure guides to the structure only, to the approval of the Consultant.

- .2 Generally, locate and provide expansion compensation where shown and/or as required to suit installed piping layout.
- .3 Provide double pipe alignment guides in horizontal piping at each side of expansion compensation facilities to permit movement in the axial direction only. Secure guides to the building structure only.
- .4 Provide a pipe guide at each side of expansion joints in vertical risers.

3.3 Installation of Pipe Anchors

- .1 Provide anchors to secure piping to the structure. Locate anchors generally where shown as shown and/or as required withstand all anticipated static and dynamic loading conditions which may act upon the mechanical piping system. Exact locations to suit the installed piping layout and as per the requirements of the engineered anchor shop drawings.
- .2 When installation of anchors is complete, arrange, and pay for the anchor design Structural Engineer to visit the site to review the anchor installation. Submit a signed letter from the Design Engineer and bearing the Engineer's stamp to confirm that each anchor is properly installed in accordance with design requirements.

3.4 Installation of Steam Main Back Pressure Regulator

- .1 Provide a back pressure regulator assembly in the steam discharge piping of each boiler between the boiler and the steam header. Install each assembly, complete with strainer, in accordance with the manufacturer's instructions. Test and adjust as required.

3.5 Installation of Steam Separators

- .1 Provide a steam separator assembly with thermodynamic trap module upstream of steam pressure reducing station as shown.
- .2 Each separator is to be the full line size of the pressure reducing station.

3.6 Installation of Steam Pressure Control Valves

- .1 Provide steam pressure control valve stations where shown and connect with piping as indicated, including a valved bypass.
- .2 Check and adjust each station and set at the required downstream pressure. Check relief valve operation and set to the proper operating pressure.

3.7 Installation of Pressure Relief Valves

- .1 Provide pressure relief valves where shown. Pipe the discharge of each steam safety relief valve to atmosphere through a properly sized drip pan elbow. Check and test the operation of all steam relief valves and adjust as required.

3.8 Installation of Drip Pan Elbows

- .1 Provide a drip pan elbow as close as possible to the discharge of each steam pressure relief valve. Install each drip pan elbow in accordance with the manufacturer's instructions. Provide drain piping at the bottom of the elbow and ensure that the steam vent pipe to atmosphere is rigidly supported independent of the drip pan elbow.

3.9 Installation of Steam Vent Exhaust Heads

- .1 Provide an exhaust head for the termination of each steam vent to atmosphere. Install each head a minimum of 200 mm (8") above the roof in accordance with the manufacturer's instructions. Coordinate installation with the roofing trade to ensure that piping to each exhaust head assembly is properly flashed into roof construction. Confirm exact locations prior to installation.
- .2 Do not locate exhaust heads within 300 mm (12") of roof walkways and within 3 m (10') of equipment air intakes or building openings.

3.10 Installation of Air Vents

- .1 Provide proper air vents at the end of all steam mains, and at the top of all steam risers.

3.11 Installation of Strainers

- .1 Provide a strainer at each steam drip trap, and in piping where shown. Locate strainers so that baskets are easily removable. Clean strainer baskets after piping system flushing and cleaning is complete.

3.12 Installation of Pump Trap

- .1 Provide a pump trap where shown and install in accordance with manufacturer's instructions.

3.13 Installation of Steam Drip Traps

- .1 Provide a steam trap assembly in the condensate return piping from each piece of equipment, at the base of each riser, in horizontal steam mains as specified, and wherever it is necessary to raise the piping to avoid a reduction in ceiling height or minimum headroom allowances. Size traps to correspond with condensate return piping sizes unless otherwise specified. Equip each trap with shut-off valve(s), two unions located immediately upstream and downstream of the trap, a strainer, sensing chamber, and a dirt pocket.
- .2 **Thermodynamic Traps:** Drip traps in steam mains with a working pressure greater than 140 kPa (20 psi) and greater piping to equipment, unless otherwise specified, are to be thermodynamic type traps.
- .3 **Float and Thermostatic Traps:** Drip traps in low pressure steam mains less than 140 kPa (20 psi) and in piping less than 140 kPa (20 psi) to equipment, unless otherwise specified are to be float and thermostatic type traps.
- .4 **Balanced Pressure Thermostatic Traps:** Drip traps for direct steam radiation units are to be balanced pressure thermostatic type.
- .5 Connect low pressure condensate drip piping from steam drip trap assemblies into condensate return piping unless otherwise shown on the drawings or specified herein. Do not connect condensate return piping into the discharge of traps draining steam mains.

3.14 Installation of Steam Drip Trap Testing Components

- .1 Provide a drip trap testing sensor chamber in piping downstream of each trap to be tested as indicated on the drawings.
- .2 For each trap which is to be tested but is inaccessible (concealed, or exposed but located at high level or otherwise inaccessible), provide a wall mounting remote test point and accurately identify the test point to indicate the trap and sensor chamber it is associated with. Connect the sensor chamber and remote test point with wiring (in conduit) of a type recommended by the test equipment manufacturer. Provide terminal strips for connecting conductors. Neatly secure wiring in place at close intervals.
- .3 For groups of traps which are to be tested but are inaccessible, provide a wall mounting remote multiple test point. Connect sensor chambers associated with the remote traps to test point terminals with wire (in conduit) of a type recommended by the test equipment manufacturer. Provide terminal strips for connecting conductors. Neatly secure wiring in place at close intervals. Provide a typed, glazed, and framed directory adjacent the remote multiple test point to indicate the traps connected to the test point selector dial.
- .4 Confirm test point locations prior to roughing-in.
- .5 Supply a hand-held test indicator with battery and turn the unit over to the Owner prior to Substantial Performance.

3.15 Installation of Steam Vacuum Breakers

- .1 Provide vacuum breakers in steam inlet piping after each temperature control valve to closed steam actuated vessels such as coils and heat exchangers, and in steam piping wherever required to control induced vacuum within safety limits when condensate is discharged into the return line by gravity. Mount each vacuum breaker vertically, unless otherwise specified.

3.16 Installation of Flash Tanks

- .1 Provide flash tanks for high pressure condensate return or drip piping where shown and/or required. Extend and connect the high pressure condensate return piping to the flash tanks, and extend and connect the low pressure condensate piping from the flash tanks into a low pressure condensate return main.

3.17 Installation of Flash Condensers

- .1 Provide flash condensers where shown to ensure that condensate dumped to drain is maximum 60°C (140°F).
- .2 Coordinate installation with work of the mechanical work Section entitled Domestic Water Piping and Valves where domestic water connections are specified.

3.18 Installation Of Steam Metering Equipment

- .1 Provide steam metering equipment for the steam boiler plant.
- .2 Ensure that each transducer is sized by the manufacturer to suit maximum load and pressure, and that it is located in straight pipe in accordance with the manufacturer's instructions.
- .3 Install the signal conditioning units and flow computers.

- .4 Do all required 24 volt wiring in conduit in accordance with requirements of the electrical work. Extend 24 volt wiring from the secondary of a 115/24 volt transformer located in the Boiler Room and provided as part of the electrical work.
- .5 Include for attendance at the site for one entire eight hour day of an experienced and trained member of the metering equipment supplier's personnel to train the Owner's staff on proper equipment operation.

3.19 Installation of Pressure Powered Pump

- .1 Provide a pressure powered pump where shown.
- .2 Secure in place, level and plumb as indicated on drawings and in accordance with manufacturer's instructions.

3.20 Installation of Condensate Pump Set

- .1 Provide a condensate pump set where shown.
- .2 Secure the receiver by means of anchor bolts to a concrete housekeeping pad.
- .3 Connect the receiver with 20 mm ($\frac{3}{4}$ ") diameter valved condensate piping, vent piping the full size of the receiver vent tapping, 12 mm ($\frac{1}{2}$ ") diameter valved drain piping in receiver inlet piping ahead of the shut-off valve, and overflow piping connected to the drain piping downstream of the drain valve. Connect the pump discharge condensate return piping containing a shut-off valve and a check valve, and a 20 mm ($\frac{3}{4}$ ") diameter drain valve immediately downstream of the shut-off valve.
- .4 Check operation of each float valve and adjust as required.
- .5 Check operation of duplex set alternator and adjust as required.

3.21 Installation of Pressure Powered Condensate Return Pumps

- .1 Provide steam pressure powered condensate return pumps where shown.
- .2 Secure each pump in place on a concrete housekeeping pad and connect with piping in accordance with the manufacturer's instructions, including overflow piping and vent. Provide an adequately sized condensate collecting header if required. Maintain a minimum of 300 mm (12") head from the lowest point of the application to the top of the pump.
- .3 Install the insulation covers supplied loose with the pumps.

3.22 Equipment Certification, Start-Up, and Training

- .1 For all piping specialties such as steam trap testing equipment, pumps, flow meters, and similar items, include for each item or group of similar items, manufacturer's on-site certification, start-up, and O & M training as follows:
 - .1 **Equipment and System Manufacturer's Certification:** Refer to the article entitled Equipment and System Manufacturer's Certification in the mechanical work Section entitled Mechanical Work General Instructions.
 - .2 **Start-Up:** Refer to the article entitled Equipment and System Start-up in the mechanical work Section entitled Mechanical Work General Instructions.

- .3 **Demonstration and Training:** Refer to the article entitled Equipment and System O&M Demonstration & Training in the mechanical work Section entitled Mechanical Work General Instructions. Include for four hours of on-site operation demonstration and training session. The training is to be a full review of all components including but not limited to a full operation and maintenance demonstration, with abnormal events.

3.23 Seismic Control And Restraint

- .1 Brace and secure each piping specialties in accordance with requirements specified in the mechanical work Section entitled Seismic Control and Restraint.

END OF SECTION

PART 1 - GENERAL

1.1 Submittals

- .1 **Shop Drawings/Product Data:** Submit shop drawings/product data sheets for all products specified in Part 2 of this Section except for pipe and fittings. Ensure that shop drawings/product data sheets confirm that products proposed meet all requirements of the Contract Documents.
- .2 **Refrigerant Piping Schematics:** Submit, in shop drawing form, a schematic piping diagram for each refrigerant piping system indicating pipe sizes, slopes, valves, traps, and piping specialties. Piping schematics must be reviewed, approved, and signed by the refrigeration equipment manufacturers prior to being submitted to the Consultant for review.
- .3 **Certification Reports:** Submit letters from equipment suppliers certifying proper installation and start-up of the piping systems and equipment as specified in Part 3 of this Section.

1.2 Quality Assurance

- .1 **Codes and Standards:** Refrigerant piping systems are to be in accordance with CSA B52, Mechanical Refrigeration Code, and any applicable local Codes and Regulations.
- .2 Refrigerant piping installing contractor is to be certified by Technical Standards and Safety Authority (TSSA). Installing contractor is to install refrigerant piping in accordance with manufacturer's installation instructions and in accordance with local codes. Contractor is responsible for all regulatory approvals, if required. Upon completion of installation, documentation of refrigerant amount, test certificates and verification documentation, etc., is to be provided in a binder, in accordance with requirements of local authorities having jurisdiction.
- .3 **Installation Personnel:** Refrigerant piping and direct expansion refrigeration equipment must be installed by or under direct on site supervision of a licensed journeyman refrigeration mechanic.

PART 2 - PRODUCTS

2.1 Pipe, Fittings and Joints

- .1 Type ACR hard drawn seamless copper refrigerant tubing to ASTM B280, factory degreased, dehydrated and capped or nitrogen filled and capped, complete with factory washed and bagged wrought copper soldering fittings to ASME B16.22, and brazed joints made with high melting point silver brazing alloy conforming to AWS Classification BcuP-5.

2.2 Piping Line Sets

- .1 Equal to Great Lakes Copper Inc. "EZ-Roll" soft annealed copper to ASTM B280, suitable for use with the refrigerant involved, factory cleaned and capped, and with sizes and lengths as required.

2.3 General Re: Valves and Piping Specialties

- .1 All refrigerant valves and piping specialties specified below are to factory cleaned, degreased, and supplied to the site with capped ends.

2.4 Shut-Off Valves

- .1 **Ball Valves:** Mueller Industries Inc. "Ballmaster", ¼ turn, CSA certified forged brass ball valves, each suitable for a maximum working pressure of 3445 kPa (500 psi) and complete with carbon filled Teflon ball seals, two O-ring stem seals, a gasketed seal cap, a flow direction arrow cast into the body, a ball position indicator on the stem, and extended copper tube connections to permit brazing the valve into the line without disassembling the valve.
- .2 Acceptable manufacturers are:
 - .1 Mueller Industries Inc.;
 - .2 Sporlan Valve Co.;
 - .3 Superior Refrigeration Products/Sherwood.
- .3 **Diaphragm Valves:** Mueller Industries Inc. "Linemaster" forged brass, frost-proof, Type 1 Series, CSA certified packless diaphragm valves, each suitable for a 3445 kPa (500 psi) working pressure and complete with an O-ring to prevent moisture from entering the diaphragm chamber, one phosphor bronze and two stainless steel diaphragms, and extended copper tube brazing connections.
- .4 Acceptable manufacturers are:
 - .1 Mueller Industries Inc.;
 - .2 Sporlan Valve Co.;
 - .3 Superior Refrigeration Products/Sherwood.

2.5 Check Valves

- .1 Mueller Industries Inc. "Checkmaster" straight through type for valves 6.4 mm to 16 mm (¼" to 5/8") diameter, globe type for valves 22 mm (7/8") diameter and larger, each complete with extended tubing for brazing connections, and as follows:
 - .1 straight through type check valves are to be complete with a machined brass gasketed body, phosphor bronze spring, and neoprene seat;
 - .2 globe type check valves are to be complete with a cast bronze body, forged brass cap, phosphor bronze spring, Teflon seat disc, and neoprene O-ring seal.
- .2 Acceptable manufacturers are:
 - .1 Mueller Industries Inc.;
 - .2 Sporlan Valve Co.;
 - .3 Superior Refrigeration Products/Sherwood.

2.6 Piping Traps

- .1 Mueller Industries Inc. Style No. WE-554P brazing end copper "P" traps.

-
- .2 Acceptable manufacturers are:
 - .1 Mueller Industries Inc.;
 - .2 Sporlan Valve Co.;
 - .3 Superior Refrigeration Products/Sherwood.

2.7 Pressure Vessel Relief Valves

- .1 Mueller Industries Inc. "Safety-master", factory set pressure relief valves, straight through or angle type as required, each constructed in accordance with requirements of ANSI Code B9.1 and the ASME Code for Unfired Pressure Vessels, and each complete with a brass body, neoprene seat disc, and lead seal and locking wire.
- .2 Acceptable manufacturers are:
 - .1 Mueller Industries Inc.;
 - .2 Sporlan Valve Co.;
 - .3 Superior Refrigeration Products/Sherwood.

2.8 Refrigerant Liquid Moisture Indicators

- .1 Mueller Industries Inc. "Vuemaster", forged brass, triple sealed, CSA certified liquid moisture indicators, each suitable for a maximum working pressure of 3445 kPa (500 psi) and complete with a liquid indicator which shows "FULL" when the system is fully charged with refrigerant and remains blank when there is a restriction or shortage of refrigerant in the liquid line, a moisture indicator which changes colour from blue to pink when moisture is present in the system, a plastic dust cover, and extended copper tube brazing connections.
- .2 Acceptable manufacturers are:
 - .1 Mueller Industries Inc.;
 - .2 Sporlan Valve Co.;
 - .3 Superior Refrigeration Products/Sherwood.

2.9 Liquid Line Filter-Drier

- .1 Mueller Industries Inc. "Drymaster Micro-Guard" CSA certified filter-driers, each suitable for a maximum 3445 kPa (500 psi) working pressure and complete with a combination of desiccants in a fluted briquette for drying, and a fluted briquette type filter.
- .2 Acceptable manufacturers are:
 - .1 Mueller Industries Inc.;
 - .2 Sporlan Valve Co.;
 - .3 Superior Refrigeration Products/Sherwood.

2.10 Flexible Piping Connections

- .1 Senior Flexonics Canada "VIBRA-SORBERS" phosphor bronze construction, factory cleaned, dried, and sealed flexible piping connections with copper tube brazing ends.

-
- .2 Acceptable manufacturers are:
 - .1 Senior Flexonics Canada;
 - .2 The Metraflex Co.

2.11 Thermostatic Expansion Valves

- .1 Factory tested, balanced port design thermostatic expansion valves, with exact selection to suit the application and refrigerant used, each complete within a replaceable stainless steel diaphragm and welded element construction thermostatic element charged with hydraulic fluid, and removable inlet strainer.
- .2 Acceptable manufacturers are:
 - .1 Mueller Industries Inc.;
 - .2 Sporlan Valve Co.;
 - .3 Superior Refrigeration Products/Sherwood.

2.12 Electronic Expansion Valves

- .1 Factory tested, mechanically driven by stepped motor that receives its drive signals from a separate control board hard-wired to the valve.
- .2 Acceptable manufacturers are:
 - .1 Bitzer Canada Inc.

PART 3 - EXECUTION

3.1 Demolition

- .1 Do all required refrigerant piping system demolition work. Refer to demolition requirements specified in the mechanical work Section entitled Demolition and Revision Work.

3.2 Installation Of Refrigerant Piping, Valves and Specialties

- .1 Refrigerant piping shall not be installed vertically through floors from one storey to another, except where the piping is enclosed in an approved rigid and tight continuous fire-resistant chase or pipe that is completely sealed to floors not served by the refrigeration system. The chase or pipe shall be vented to the outdoors.
- .2 Provide all required refrigerant piping. Piping is to be type ACR copper with wrought copper fittings. Install piping in accordance with requirements of reviewed refrigerant piping schematics referred to in Part 1 of this Section.
- .3 Make all refrigerant piping joints using a light coat of approved brazing flux applied to both pipe and fitting. Do not use acid flux. During the brazing process, ensure that the pipe and fittings are kept full of nitrogen or carbon dioxide to prevent scale formation inside the pipe and fitting.
- .4 Where shown or specified, use soft copper refrigerant piping line sets.
- .5 Provide shut-off valves to isolate each piece of equipment if shut-off valves are not supplied integral with the equipment. Shut-off valves inside the building are to be ball or

diaphragm type. Shut-off valves outside the building are to be diaphragm type.

- .6 Provide a refrigerant charging valve for each system if such a valve is not supplied integral with the equipment.
- .7 Provide all refrigerant piping accessories shown and/or required and install in accordance with the manufacturer's recommendations.
- .8 Provide all required refrigerant.
- .9 Provide flexible connections at piping connections to roof mounted condensing units. Install in accordance with the manufacturer's instructions.
- .10 Provide expansion valves where shown and/or required, each matched to the coil and installed in accordance with the manufacturer's instructions.

END OF SECTION

PART 1 – GENERAL

1.1 Submittals

- .1 Submit shop drawings/product data sheets for all water treatment chemical feed equipment and associated hardware.
- .2 Submit product literature sheets for all chemicals, as well as WHMIS Material Safety Data Sheets for all chemicals.
- .3 Submit water treatment manufacturer/supplier certification letters as specified in Part 3 of this Section.
- .4 Submit water treatment test sets and spare chemicals as specified below and in Part 3 of this Section.

PART 2 – PRODUCTS

2.1 Characteristics of Chemicals and Spare Chemicals

- .1 Chemicals specified in this Section are to be non-toxic when released to atmosphere, non-corrosive and non-staining if a leak occurs, and compatible with all system components.
- .2 Chemicals must be approved by governing authorities for release into Municipal sewer system.
- .3 For each treatment system for which chemicals are supplied, supply and hand to Owner, at Substantial Performance of the Work, spare chemical in original containers/packaging sufficient for 2 months of treatment system operation.

2.2 Manufacturers/Suppliers of Chemicals and Feed Equipment

- .1 Acceptable manufacturers/suppliers are:
 - .1 Solenis;
 - .2 Klenzoid Inc.;
 - .3 Magnus Canada;
 - .4 Chem-Aqua Inc.;
 - .5 Cleaver-Brooks Inc.;
 - .6 Suez Water Technologies;
 - .7 Excalibur Water Systems;

2.3 Piping System Flushing and Cleaning Chemical

- .1 Liquid form alkaline type cleaner consisting of a concentrated blend of highly active penetrating agents and detergents with a 12.5 pH and specifically formulated to remove oil, mill scale and oxides from piping and equipment.

2.4 Closed Heat Transfer System Treatment

- .1 Chemicals, chemical feed equipment, and test equipment to control corrosion in closed heat transfer circulating systems as indicated on drawings and as specified below.
- .2 Enamelled steel or cast iron by-pass feeders sized as shown, 2060 kPa (300 psi) rated and complete with 20 mm ($\frac{3}{4}$ ") diameter NPT pipe connection tappings, and a screw-on cast iron cap with "Buna N" "O" ring seal.
- .3 By-pass filter and flow indicator assembly equal to a Shelco Inc. FOS78, 1725 kPa (250 psi) rated replaceable cartridge filter assembly with a stainless steel housing and 20 mm ($\frac{3}{4}$ ") diameter piping connections, sized for approximately 5% of rated circulating pump flow and complete with a minimum of 6, 20 micron filter cartridges, and a sight flow indicator equal to an Anderson Midwest Model 350SS with 20 mm ($\frac{3}{4}$ ") diameter piping connections.
- .4 Piping tee mounting coupon holders, each complete with 25 mm (1") diameter NPT plugs with a minimum of one coupon for copper and one coupon for steel.
- .5 Chromate free, nitrite/borate type corrosion inhibitor suitable for use with both ferrous and non-ferrous metals.
- .6 Test kit for measuring inhibitor level.

PART 3 – EXECUTION

3.1 Piping System Flushing and Cleaning

- .1 After new heat transfer system piping has been installed and leakage testing has been satisfactorily completed, but before mechanical equipment start-up and performance tests, flush and chemically clean piping systems.
- .2 Provide required temporary piping connections, including bypass piping to isolate dirt sensitive mechanical plant equipment. Remove instrumentation such as flow meters and switches, orifice plates, meter valves and similar devices and plug pipe openings. Reinstall when flushing and cleaning work has been certified complete by chemical manufacturer/installer. Ensure control valves are operational and fully open during flushing and cleaning.
- .3 Prior to chemical cleaning, flush piping, including dead ends, with water to remove loose solids. Clean all strainers. Replace chemical feeder line filters as required. Flush and drain until water runs clear.
- .4 When flushing with water is complete, fill systems with fresh clean water. Meter amount of water required to fill each system or otherwise calculate system capacity. Ensure all air is vented from systems. Add cleaning chemical as instructed by chemical manufacturer and circulate solution for a period of time and at a temperature as required to produce a clean piping system. Conduct daily pH, conductivity, and total iron tests in accordance with chemical supplier's instructions.

-
- .5 After chemical cleaning when test results indicate a clean system, drain solution from piping, refill with clean water and circulate water for a minimum of 24 hours to flush out remaining chemical solution, then drain water from piping using all drain points and again clean all system strainers and replace filters. Arrange for chemical supplier to check each system after flushing and cleaning is complete and to certify in writing that flushing and cleaning procedures have been properly performed. Submit a copy of the certification letter. Fill systems.

3.2 Installation of Closed Heat Transfer System Treatment

- .1 After flushing and cleaning procedures have been certified complete, provide a by-pass chemical feeder, a cartridge filter assembly, and corrosion test coupons for each closed heat transfer system. Install in accordance with requirements of drawing details.
- .2 Supply and feed into each system sufficient chemical to charge system to proper concentrations of chemical and maintain proper levels in system until Substantial Performance of the Work.

3.3 Manufacturer's Certification, Start-Up, and Training

- .1 For all water treatment equipment include for on-site certification, start-up supervision, and system training by treatment chemical manufacturer's representative as follows:
 - .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 4 hours of 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

PART 1 - GENERAL

1.1 Submittals

- .1 **Shop Drawings/Product Data:** Submit shop drawings/product data sheets for all products specified in this Section except shop fabricated ductwork and fittings.
- .2 **Test Data:** Submit duct leakage test data prior to ductwork being covered from view.

PART 2 - PRODUCTS

2.1 Galvanized Steel Ductwork

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

2.2 Flexible Metallic Ductwork

- .1 **Bare:** 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:** 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 (1½") thick, 12 kg/m³ (0.75 lb/ft³) density fibreglass insulation with a vinyl jacket meeting flame spread and smoke developed requirements of CAN/ULC-S102.

2.3 Flexible Fabric Ductwork

- .1 **Bare:** Equal to Flexmaster Canada Ltd. "Fabriflex" Fab 4 ULC listed and labelled Class 1 flexible fabric duct consisting of vinyl coated fibreglass cloth mechanically bonded to a corrosion resistant galvanized steel helix.
- .2 **Insulated:** Equal to Flexmaster Canada Ltd. "Fabriflex" Fab 4T ULC listed and labelled Class 1 flexible fabric duct consisting of vinyl coated fibreglass cloth mechanically bonded to a corrosion resistant galvanized steel helix and factory insulated with 25 mm (1") thick glass fibre insulation with a polyethylene vapour barrier jacket.

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 maximum flame spread rating of 5 and smoke developed rating of 0.

2.5 Acoustic Lining

- .1 Minimum 25 mm (1") thick acoustic lining material meeting NFPA 90A requirements and flame spread and smoke developed fire hazard ratings of CAN/ULC-S102, flexible for round ducts, board type for rectangular ducts, consisting of a bonded fiberglass mat coated on the inside (airside) face with a black fire-resistant coating.

PART 3 - EXECUTION

3.1 Fabrication and Installation of Galvanized Steel Ductwork

- .1 Provide all required standard galvanized steel ductwork, rectangular and/or round and/or flat oval as shown. **Note** that where rectangular ductwork is shown, round or flat oval ductwork of equivalent cross-sectional area is acceptable.
- .2 Unless otherwise specified, construct and install ductwork in accordance with ANSI/SMACNA HVAC Duct Construction Standards Metal and Flexible to suit the duct pressure class designation of **minimum** 625 Pa (2.5" w.c.) positive or negative as applicable, a minimum velocity of 10 m/s (2000 fpm), and so that the ductwork does not "drum". All flat surfaces of rectangular ductwork are to be cross-broken. Duct system sealing is to meet ANSI/SMACNA Seal Class A requirements.
- .3 Variable air volume ductwork from supply fans to boxes is to be as above but rectangular duct take-offs are to be 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 the double taper side is to have an included angle of minimum 60°.
- .4 **Duct Routing and Dimensions:** Confirm the routing of all ductwork at the site and site measure ductwork prior to fabrication. Note that duct dimensions may be revised to suit site routing and building element requirements, if dimension revisions are reviewed with and approved by the Consultant. Duct routing and/or dimension revisions to suit conditions at the site are not grounds for a claim for an extra cost.
- .5 **Ducts Run Within or Through OWSJ:** Refer to structural drawings. Where ductwork is to be run within or through open web steel joists, note that ductwork shown on the mechanical drawings is schematic only and is to be altered as required to suit the steel joist configuration, spacing, panel points, and cross-bridging at no additional cost.
- .6 **Ductwork Located at Sprayed Fireproofing:** Wherever ductwork is required at locations where sprayed fireproofing is applied to building construction, install the ductwork only after the fireproofing work is complete and do not compromise the fire rating of the sprayed fireproofing.
- .7 **Automatic Control Components:** Install (but do not connect) all duct system mounted automatic control components supplied as part of the automatic control work.
- .8 **Heat Transfer Equipment Connections:** Where indicated, provide duct connections to fan powered heat transfer equipment with integral coils.

-
- .9 **Separate Hot Water Reheat Coils:** Flange connect ductwork to hot water reheat coils in accordance with requirements of ANSI/SMACNA HVAC Duct Construction Standards Metal and Flexible. The coils will be suspended independent of connecting ductwork as part of the heat transfer work.
 - .10 **Rectangular Duct Support Inside Building:** Support horizontal rectangular ducts inside the 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 all ducts that are exposed, and all concealed ducts wider than 500 mm (20").
 - .11 **Round and Flat Oval Duct Support Inside Building:** Support round and flat oval ducts inside the 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 the top of the duct to a hanger rod, all similar to Ductmate Canada Ltd. type "BA". If the duct is insulated, size the strap to suit the diameter of the insulated duct.
 - .12 **Flanged Duct Joints:** Where flanged duct joints are used, do not locate the 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.**
 - .13 **Support of Roof Mounted Ducts:** As specified in the mechanical work Section entitled Duct System Dampers and Accessories.
 - .14 **Watertight Ductwork:** Where watertight horizontal ductwork is required, construct the ducts without bottom longitudinal seams. Solder or weld the joints of bottom and side sheets. Seal all other joints with duct sealer. Slope horizontal duct to hoods, risers, or drain points. Provide the drain points. Provide watertight ductwork for:
 - .1 all galvanized steel ductwork outside the building or otherwise exposed to the elements;
 - .2 fresh air intakes;
 - .3 wherever else shown.
 - .15 **Leakage Testing:**
 - .1 Leakage testing is to be performed by the Testing, Adjusting and Balancing Agency in accordance with the SMACNA HVAC Air Duct Leakage Test Manual and is to be witnessed by the Consultant.
 - .2 Ductwork leakage is not to exceed one percent of the total air quantity handled by the respective fans.
 - .3 Leakage test the following ductwork:
 - .1 All supply, exhaust and return air duct systems 25' (7.5 m) and longer;
 - .2 Other ductwork as required.
 - .4 Be responsible for the 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 and ensure notice is given to Consultant so that they may witness testing. Be present for all 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 **Application of Sealants:** 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 the sealant.
- .17 **Protective Coating for Exposed Exterior Ducts:** Clean exterior exposed (uninsulated) ducts with a heavy full coverage of Bakor #410-02 black metal paint.
- .18 **Connection of Dissimilar Metal Ducts:** Where dissimilar metal ducts are to be connected, isolate the ducts by means of flexible duct connection material as specified in the Section entitled Duct System Dampers and Accessories.
- .19 **Exposed Round Gymnasium Ductwork:** All round exposed ductwork in the Gymnasium is to be two metal gauges heavier than the standard metal gauge for the same size duct, and duct hangers are to be pairs of 9.5 mm ($\frac{3}{8}$ ") diameter hanger rods secured to 40 mm ($1\frac{1}{2}$ ") wide #12 gauge galvanized steel split clamps around the full circumference of the duct at maximum 1.8 m (72") centres. Double nuts and lock washers are to be provided on each hanger rod above and below each clamp.
- .20 **Ductwork In Equipment Rooms:** All ducts with a dimension of 600 mm (24") and larger and located in mechanical equipment rooms of any kind are to be equipped hanger rods equipped with double deflection neoprene rod isolation hangers properly sized for the associated load. Also refer to the Section entitled Seismic Control and Restraint.
- .21 **Seismic Requirements:** In addition to SMACNA duct construction standards specified above, ductwork is to be constructed and installed to meet seismic requirements of the British Columbia Building Code and ANSI/SMACNA The Seismic Restraint Manual: Guidelines for Mechanical Systems.

3.2 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 the 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.

3.3 Duct System Protection, Cleaning and Start-Up

-
- .1 Clean all new ductwork to meet the requirements of the NADCA ACR Standard.
 - .2 Temporarily cover all open ends of ducts during construction.
 - .3 Vacuum all dirt and foreign matter from the entire duct systems and clean duct system terminals and the interior of air handling units prior to operating fans.
 - .4 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.
 - .5 Provide cheesecloth over all duct system inlets and outlets and run the system for twenty-four hours, after which remove the cheesecloth, the construction filters, and install new permanent filters.
 - .6 Include all labour for a complete site walk-through with testing and balancing personnel following the route of all duct systems to be tested, adjusted and balanced for the purpose of confirming the proper position and attitude of dampers, the location of pitot tube openings, and any other work affecting the testing and balancing procedures. Perform all corrective work required as a result of this walk-through.

END OF SECTION

PART 1 - GENERAL

1.1 Submittals

- .1 **Shop Drawings/Product Data:** Submit shop drawings/product data sheets for all products specified in this Section. Shop drawings and product data sheets must confirm that the products proposed meet all requirements of the Contract Documents.
- .2 **Colour Chart(s):** Submit manufacturer's colour chart(s) for all items for which a finish colour is to be selected.

PART 2 - PRODUCTS

2.1 Round to Rectangular Duct Connections

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

2.2 Splitter Dampers

- .1 Minimum #20 gauge damper blade constructed of the same material as the duct, reinforced as required to suit blade size, system velocity, and to prevent "chatter", and complete with operating hardware equal to Dyn Air 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.

2.3 Air Turning Vanes

- .1 For square elbows - multiple-radius turning vanes, interconnected with bars, adequately reinforced to suit the pressure and velocity of the system, constructed of the same material as the 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 degree opposed blade volume control damper, constructed of the same material as the duct it is associated with and in accordance with requirements and details in ANSI/SMACNA HVAC Duct Construction Standards Metal and Flexible.

2.4 Manual Balancing (Volume) Dampers

- .1 Flanged and drilled, single or parallel blade (depending on damper size) manual balancing dampers, each constructed of the same material as the connecting ductwork unless otherwise specified, each designed to maintain the internal free area of the connecting duct, and each complete with:
 - .1 a hexagonal or square shaft extension through the 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 the blade from moving more than 90°;
- .4 linkage for multiple blade dampers;
- .5 a locking hand quadrant damper operator with, for insulated ducts 50 mm standoff mounting.
- .2 **Rectangular Dampers:** Nailor Industries Inc. #SP1010 FF 16G LC BS NS, maximum size 1.2 m x 1.2 m (4' x 4') for a single damper.
- .3 **Round Dampers:** Nailor Industries Inc. #1090 BS, 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 the same material as the damper and designed for tight and secure mounting of the individual dampers.
- .5 Acceptable manufacturers are:
 - .1 Nailor Industries Inc.;
 - .2 T.A. Morrison & Co. Inc. "TAMCO";
 - .3 NCA Manufacturing Ltd.;
 - .4 Price Industries Ltd.;
 - .5 Ruskin Co.

2.5 Backdraft Dampers

- .1 T. A. Morrison & Co. Inc. "TAMCO" counterbalanced backdraft dampers, Series 7000 WT for vertical mounting, Series 7000 CW for down (horizontal) mounting, 65 mm (2½") deep, sized as shown and complete with:
 - .1 extruded aluminum frame and blades, minimum 1.58 mm (1/16") thick, with captive extruded silicone blade gaskets and side seals in slots integral with the aluminum extrusions;
 - .2 damper blade counterweights internal to the frame and consisting of adjustable weights fastened to brackets which are riveted to the blades;
 - .3 dual PVC linkage tracks at each end of the blades, and non-corrosive linkage with hard alloy aluminum pivot arm and Ticona "Celcon" acetal copolymer bearings.
- .2 Acceptable manufacturers are:
 - .1 T.A. Morrison & Co. Inc. "TAMCO";
 - .2 Nailor Industries Inc.;
 - .3 NCA Manufacturing Ltd.;
 - .4 Price Industries Ltd.;
 - .5 Ruskin Co.

2.6 Fusible Link Dampers

- .1 Curtain blade type, dynamic, galvanized steel (unless otherwise specified) fusible link dampers, ULC classified to Standard 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 100°C (212°F) rated standard fusible link.
- .2 Fusible link dampers are to be Type "B" or Type "C" (as required) with the folded curtain blade out of the air stream except where damper size or location requires the use of type "A" dampers with the curtain blade in the air stream.
- .3 Fusible link dampers in ductwork other than galvanized steel are to be as specified above but constructed of Type 316 stainless steel.
- .4 Acceptable fusible link damper manufacturers are:
 - .1 Nailor Industries Inc.;
 - .2 Price Industries Ltd.;
 - .3 NCA Manufacturing Ltd.;
 - .4 Ruskin Co.

2.7 Motorized Smoke Dampers

- .1 Fail-safe, opposed blade, galvanized steel (unless otherwise specified) smoke dampers, ULC listed and labelled, leakage Class I smoke rated, normally closed, Type "B" or "C" as required, and complete with a factory installed and tested 115 volt electric actuator, jamb seals, and linkage is to be concealed in the frame, out of the airstream. Smoke dampers are to meet requirements of CAN/ULC-S112.1-10, and NFPA 90A, 92A, and 92B.
- .2 Acceptable products are:
 - .1 Nailor Industries Inc. Series 1210;
 - .2 Price Industries Ltd.;
 - .3 NCA Manufacturing Ltd.;
 - .4 Ruskin Co.

2.8 Barometric Relief Dampers

- .1 Equal to Greenheck BR-30 series vertical mounted backdraft damper sized as shown, suitable for pressures to 500 Pa (2"wg), velocities to 10.2 m/s (2000 fpm) and temperatures to 82°C (180°F), and complete with:
 - .1 1.5 mm (16 ga.) insert mount stainless steel hat channel frame with 127 mm (5") depth;
 - .2 1.6 mm (0.063") thick formed aluminium, eccentrically pivoted blades;

- .3 9.5 mm (3/8") square stainless steel axles with Type 316 ball bearings with acetal races;
- .4 on-blade adjustable counterbalance weight;
- .5 internal stainless steel blade-to-blade linkage, side mounted (out of airstream);
- .6 selectable start open from 12 Pa to 32 Pa (0.05 to 0.13"wg).
- .2 Acceptable manufacturers are:
 - .1 Greenheck Fan Corp.;
 - .2 T.A. Morrison & Co. Inc. "TAMCO";
 - .3 Nailor Industries Inc.;
 - .4 NCA Manufacturing Ltd.;
 - .5 Ruskin Co.

2.9 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 Waterproof, flameproof, high temperature flexible connection material meeting requirements of NFPA 90A, consisting of a woven glass fibre fabric coated on both sides with silicone rubber. Acceptable products are:
 - .1 Duro-Dyne Canada Inc. "THERMAFAB";
 - .2 Dyn Air Inc. "SILICON HI-T".

2.10 Roof Duct Supports

- .1 Equal to Lexcor (Lexsuco Corp.) Series SS-A215 "Flash-Tite" adjustable height, insulated aluminum structural supports, each complete with two-piece telescoping flashing, a baseplate to suit the application, a threaded cap with plate, and a 12 mm x 40 mm (1/2" x 1 1/2") threaded stainless steel top stud.
- .2 Equal to Portable Pipe Hangers (Canada) Inc. Model PHP-D adjustable duct support assemblies sized to suit the duct size, each assembly complete with injection moulded recycled plastic and carbon black bases and tubular hot dip galvanized steel framing.

2.11 Fan And Duct System Explosion/Implosion Prevention Access Doors

- .1 McGill AirFlow Pressure-Relief (positive or negative) access doors constructed of the same material as the duct or plenum they are associated with, each complete with a sealing gasket, special latches, and cover with safety chain.

- .2 Size access doors to match requirements of the system so that the pressure drop through the open blow-out door at the required flow rate will not exceed the rated pressure of the duct system.
- .3 Acceptable manufacturers are:
 - .1 McGill AirFlow;
 - .2 United Enertech;
 - .3 Greenheck Fan Corp.

2.12 Duct Access Doors

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

2.13 Ductwork Drain Points

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

2.14 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.

2.15 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 the drawings, and constructed so as to be removable.

2.16 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 the 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 ($\frac{1}{2}$ ") mesh aluminum birdscreen in an aluminum frame.
- .2 **Acoustical Louvres:** Price Industries Inc. Model QA1245 300 mm (12") deep, welded, extruded alloy 3003-H14 aluminum, storm-proof, stationary, drainable acoustical louvers, AMCA water penetration and air performance certified, with high density mineral wool acoustic media secured to blades and protected by perforated aluminum, sound ratings in accordance with ASTM E90-81 and ASTM E413-73, and mounting and securing facilities as required.

- .3 Louvres are to be factory finished with a finish equal to PPG Industries "Duranar" fluoropolymer powder coating over primer with colour as selected from the manufacturer's standard colour chart or match the colour sample as per architect's direction.
- .4 Acceptable manufacturers are:
 - .1 Price Industries Inc.;
 - .2 Ventex Inc.;
 - .3 Construction Specialities;
 - .4 Nailor Industries Inc.;
 - .5 Greenheck Fan Corp.

2.17 Louvered Penthouse:

- .1 Greenheck Model WIH intake louver, sized as indicated on drawings, constructed of extruded aluminium, 2 mm (0.08") thick drainable blades with mitered corners, an insulated removable cover, able to withstand snow loading, and aluminium birdscreen in an aluminium frame. Finish is to suit Architect's direction.
- .2 Acceptable manufacturers are:
 - .1 Greenheck Fan Corp.;
 - .2 Price Industries Inc.

2.18 Louvre Blank-Off Panels

- .1 Insulated, framed, sandwich construction panels consisting of 40 mm (1½") thick rigid insulation (meeting NFPA 90A requirements) between minimum #20 gauge galvanized sheet steel with the exterior face of the panels finished to match the finish of the exterior wall louvers.

2.19 Brick and Block Vents

- .1 Equal to Price Industries Inc. vents constructed of 6063-T5 alloy extruded aluminum, sized as shown, complete with stainless steel fasteners, aluminum rod vertical supports on minimum 300 mm (12") centres, No. 2 mesh fixed aluminum screen, and all required accessories to suit the application.
- .2 The vent(s) to be factory finished with a finish equal to a baked "Kynar 500-XL" colour coat and a clear coat over cleaned and primed metal with colour as selected from the manufacturer's standard colour range.

2.20 Motorized Control Dampers

- .1 T.A. Morrison & Co. Inc. "TAMCO", 100 mm (4") deep, flanged aluminum control dampers with AMCA certified maximum leakage through a 1.2 m x 1.2 m (4' x 4') damper of 52 L/s/m² (110 ft³/min) against 1 kPa (0.145 psi) differential static pressure. Control dampers for mixing applications are to be parallel blade type. Control dampers for open-shut service are to be opposed blade type.

.2 **Standard Damper:** Series 1000 dampers complete with:

- .1 extruded 6063T5 aluminum frame and blades, each with an integral slot to receive a gasket;
- .2 extruded silicone frame gaskets and extruded EPDM blade gaskets;
- .3 slip-proof aluminum and corrosion resistant plated steel linkage concealed in the frame, equipped with self-sealing and self-lubricating bearings consisting of a Ticona "Celcon" inner bearing fixed on the hexagonal blade pin and rotating in a polycarbonate outer bearing inserted in the frame.

.3 **Insulated Damper:** As specified for standard dampers but with all four sides of the frames insulated with injected polyurethane foam, and with the blades thermally broken and insulated with expanded polyurethane foam.

.4 **Damper Motor:** Equal to Belimo CSA certified, spring return, direct coupled electric motor damper actuator, 120 volt or 24 volt as required, electronic overload protected, complete with position indicator, a housing to suit the mounting location, and additional features as required to suit the application and control sequence.

2.21 Thermostats

- .1 Equal to Johnson Controls surface wall mounting thermostats, line voltage or low voltage and single or double stage as required, each complete with a factory set 0.55 to 1°C (1 to 1.8°F) dead band, locking cover, tamper-proof concealed adjustment set point dial, and a thermometer.

2.22 Damper-Actuator Assembly (Pressure Critical Control)

- .1 Damper assemblies shall be round butterfly, to fit the ductwork. Damper material shall be 16 gauge galvanized steel, 304 stainless steel, 316 stainless steel, or Ameron coated galvanized steel to match the ductwork. Pressure drop through a fully open damper shall be less than 0.1 in H₂O at 2000 fpm velocity. Round dampers shall have two factory-formed ridges to prevent binding.
- .2 For round damper: damper assemblies shall be flange-mounted with companion rings.
- .3 For rectangular damper: Damper assemblies shall be rectangular opposed-blade type, to fit the ductwork. Dampers shall be flange-mounted.
- .4 Electric actuator shall directly mount to the actuator shaft. The actuator shall rotate 0 to 90° in less than 1.5 seconds with a maximum torque of 40 in-lb. The actuator shall operate on 24VAC power, over a temperature range of 40 to 120°F. The actuator shall be enclosed in an UL94V-0 rated plastic case. Direct or reverse action shall be field-selectable by applying an external jumper.
- .5 Acceptable Manufacturers:
 - .1 TSI;
 - .2 Arrow United Industries;
 - .3 Ruskin.

PART 3 - EXECUTION

3.1 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.

3.2 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 the drawings. Install splitter dampers so they cannot vibrate and rattle and so that the damper operation mechanisms are in an easily accessible and operable location. Ensure that operators for dampers in insulated ducts are equipped with stand-off mounting brackets.

3.3 Installation of Turning Vanes

- .1 Provide turning vanes in ductwork elbows where shown on the 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.

3.4 Installation of Manual Balancing (Volume) Dampers

- .1 Provide manual balancing dampers in all open end ductwork, in all duct mains, and wherever else shown and/or specified.
- .2 Install the dampers so that the operating mechanism is accessible and positioned for easy operation, and so that the dampers cannot move or rattle. Ensure that 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 the dimensions of the 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 five additional dampers at no additional cost.

3.5 Installation of Backdraft Dampers

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

3.6 Installation of Fusible Link Dampers

- .1 Provide fusible link dampers where shown and/or specified on the drawings. Ensure that the damper rating (1½ or 3 hr.) is suitable for the fire barrier it is associated with.
- .2 Install dampers with retaining angles on all four sides of the sleeve on both sides of the damper and connect with ductwork in accordance with the damper manufacturer's instructions and details to meet Code requirements.
- .3 Provide expansion clearance between the damper or damper sleeve and the opening in which the damper is required. Ensure that the openings are properly sized and located, and that all voids between the damper sleeve and the opening are properly sealed to maintain the rating of the fire barrier.
- .4 Where the size of the fire barrier opening requires the 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.

3.7 Installation of Motorized Smoke Dampers

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

3.8 Installation of Barometric Relief Damper

- .1 Provide barometric relief dampers where shown and/or specified.
- .2 Install in accordance with manufacturer's instructions and secure the dampers such that it does move or rattle. Ensure damper is installed square and that once installed, nothing will hinder or interfere with the blades from opening and closing.
- .3 Adjust on-blade counterbalance weight in accordance with manufacturer's instructions.

3.9 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, air handlers 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 the flexible fabric and to the fan, duct, plenum, etc., in accordance with ANSI/SMACNA HVAC Duct Construction Standards Metal and Flexible. Ensure that connections to the flexible fabric material are arranged and supported so as to not impose any external forces on the fabric.
- .3 For system _____ use high temperature flameproof flexible connection material.

3.10 Installation of Roof Mounted Duct Supports

- .1 Supply supports for roof mounted ductwork as indicated.

- .2 Hand the adjustable structural supports to the roofing trade on the roof for installation and flashing into roof construction as part of the roofing work. Accurately mark the exact locations and spacing of the structural supports and supervise installation. Provide properly sized hot dip galvanized structural steel angles between structural supports and secure in place on support studs. Support ductwork on the angles and provide galvanized steel banding to secure ducts to the angles.
- .3 Accurately mark the location and spacing of roof support assemblies. At each plastic base location, carefully scrape away loose roof ballast (gravel) and all other debris and dirt. Prime the existing membrane with a primer which is compatible with existing roofing components. Set bases in adhesive in accordance with the manufacturer's installation instructions. Scrape loose ballast back around and on the bases. Install framing, and install ductwork on the cross-members. Secure ductwork to cross-members with galvanized steel banding.

3.11 Installation of Pressure Release Doors

- .1 Provide pressure release access doors where shown to prevent duct system explosion or implosion as a result of a duct obstruction, i.e. closed fire damper, which prevents normal air flow through the system. Size access doors in accordance with requirements of Part 2 of this Section.
- .2 Where pressure release doors are shown in suction ducts or plenums, mount the access door assembly so that the door swings in and the latch mechanism is on the inside of the duct or plenum. If the latch mechanism is not accessible, provide a standard access door at the latch side of the pressure release access door for maintenance purposes.
- .3 Adjust each latch mechanism by means of the adjusting pin to suit the static pressure of the particular system in accordance with the latch mechanism manufacturer's instructions.

3.12 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 that the 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 the ductwork to suit the access door installed.

3.13 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.

3.14 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 the drawings. Rigidly secure in place but ensure the panels are removable.
- .2 Provide wire mesh panels for open-end return air ducts in ceiling spaces whether shown on the drawings or not.

3.15 Installation of Louvres

- .1 Provide louvres for wall openings where shown.
- .2 Install louver assemblies and secure in place in accordance with the manufacturer's instructions and details.
- .3 Confirm exact louver sizes and finish prior to ordering.

3.16 Installation of Louvered Penthouse:

- .1 Provide louvered penthouse where shown.
- .2 Install louver assemblies and secure in place on roof in accordance with the manufacturer's instructions and details.
- .3 Confirm exact louver size 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 the panels in place with non-ferrous hardware so that they cannot move or rattle, yet are easily removable.
- .3 Confirm exact finish of panels prior to fabrication.

3.18 Installation of Brick and Block Vents

- .1 Supply brick or block vents for installation in exterior walls where shown.
- .2 Hand the assemblies to the masonry trade for installation.
- .3 Accurately mark exact locations and coordinate installation.

3.19 Installation of Motorized Control Dampers

- .1 Provide motorized control dampers where shown. Secure in place to prevent movement or rattle, and to prevent air bypass around the damper.
- .2 Provide insulated dampers in fresh air intake ductwork or openings, and for exhaust air service at exterior walls.
- .3 Equip each damper with an electric motor actuator, 120 volt or 24 volt as required. Ensure that each actuator is equipped with all required features to suit the application.

3.20 Installation Of Thermostats

- .1 Supply thermostats for control systems and mount on an outlet box approximately 1.6 m (5') above the floor where shown.
- .2 Coordinate mounting of thermostats with the electrical work where control wiring connections are specified.
- .3 Connect thermostats with control wiring in accordance with the drawings and the wiring requirements specified below in this Section.
- .4 Check thermostat operation and adjust to design requirements.

3.21 Control Wiring

- .1 Provide all required power wiring for controls from 15A-1P circuits terminated in junction boxes adjacent to the control work and do all control wiring to connect control components.
- .2 Install wiring in conduit in accordance with electrical work wiring material and installation requirements.

END OF SECTION

PART 1 - GENERAL

1.1 Submittals

- .1 **Product Data:** Submit shop product data sheets for silencers. Include all construction, acoustic and aerodynamic performance data, and details with the submission. Acoustical data is to demonstrate that duct systems with silencers will reduce mechanical fan system noise to required levels in occupied spaces.
- .2 **Silencer Test Data:** Submit manufacturer's test data to indicate results of factory tests on the silencers prior to shipment.
- .3 **Silencer Manufacturer's Laboratory Accreditation:** Submit a copy of the silencer manufacturer's National Voluntary Laboratory Accreditation Program (NVLAP) accreditation certificate for ASTM E-477 test standards.
- .4 **Manufacturer's Certification Letter:** Submit an installation certification letter from the manufacturer of the silencers 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 twenty-five and a smoke developed rating of fifty when tested in accordance with CAN/ULC-S102, Surface Burning Characteristics of Building Materials, and Accessories.
- .3 Acceptable silencer manufacturers are:
 - .1 Kinetics Noise Control;
 - .2 Vibro-Acoustics Ltd.;
 - .3 Price Industries Ltd.;
 - .4 VAW Systems.

PART 2 - PRODUCTS

2.1 General Re: Silencers

- .1 Silencers are to be factory fabricated by the same manufacturer and are to be in accordance with the drawing schedule.
- .2 Silencer inlet and outlet dimensions are to be equal to duct sizes shown on the 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 the duct system pressure and velocity classification. Unless otherwise specified, all 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).

- .4 All perforated steel is to be adequately stiffened to ensure flatness and form, and all 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: # 16 or #10 gauge stitch-welded and caulked galvanized steel in accordance with drawing schedule.
- .4 **Circular Silencers:** Lock forming quality galvanized steel with minimum gauges as follows:
 - .1 300 mm to 660 mm (12" to 26") diameter - #22 gauge;
 - .2 675 mm to 1.52 m (27" to 60") diameter - #18 gauge;
 - .3 1.55 m to 2.13 m (61" to 84") diameter - #16 gauge.

2.3 Interior Baffle-Liner-Bullet Material

- .1 Minimum #22 gauge lock forming quality galvanized steel.

2.4 Interior Baffle Transition

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

2.5 Acoustic Media Material

- .1 Unless otherwise specified, inert, inorganic glass fibre of a density to obtain the specified acoustic performance, packed under not less than 5% compression to eliminate voids due to vibration and settling.

2.6 Acoustic Media Protection Material

- .1 Material for lining/wrapping acoustic media to help prevent shedding and erosion, as per the drawing schedule, is to be:
 - .1 polymer film material separated from the perforated metal liner with a 12 mm ($\frac{1}{2}$ ") thick acoustically transparent spacer.
 - .2 glass fibre cloth.

2.7 High Transmission Loss Casings

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

2.8 Alternative Silencer Materials

- .1 Where indicated on the drawing silencer schedule, types 304 or 316 stainless steel or aluminum silencer material is to be used.

PART 3 - EXECUTION

3.1 Installation of Silencers

- .1 Provide silencers where shown and as scheduled. Ensure that silencers are installed with airflow arrows in the direction of airflow.
- .2 Support each silencer independent of connecting ductwork.
- .3 Properly layout ductwork for silencer locations to provide a minimum of five diameters of straight duct upstream of the silencer and ten diameters of straight duct downstream of the silencer.
- .4 Unless otherwise specified, do not install silencers in walls or slabs.
- .5 Where cross-talk silencers penetrate partition walls, seal the joint between the perimeter of the silencer and the wall, on both sides of the wall, with proper acoustic caulking.
- .6 Seal all silencer connections to ducts with proper fire/smoke rated duct sealer.
- .7 When silencer installations are complete, arrange, and pay for the silencer manufacturer to examine the silencer installations. Do any corrective work required by the manufacturer, then obtain from the manufacturer and submit a signed letter certifying proper installation and operation of all silencers.

END OF SECTION

PART 1 - GENERAL

1.1 Summary

- .1 Section Includes:
 - .1 Fans, motors, accessories and hardware for commercial use.
 - .2 Sustainable requirements for construction and verification.
- .2 Related Sections:
 - .1 Division 1 – General Requirements.
 - .2 Section 20 05 05 - Common Work Results for Mechanical.

1.2 Quality Assurance

- .1 Comply with the latest edition of the following Codes and Standards.
- .2 Air Conditioning and Mechanical Contractors (AMCA)
 - .1 AMCA Publication 99, Standards Handbook.
 - .2 AMCA 300, Reverberant Room Method for Sound Testing of Fans.
 - .3 AMCA 301, Methods for Calculating Fan Sound Ratings from Laboratory Test Data.
- .3 American National Standards Institute (ANSI)/American Society of Mechanical Engineers (ASME)
 - .1 ANSI/AMCA 210, Laboratory Methods of Testing Fans for Aerodynamic Performance Rating.
- .4 Canadian General Standards Board (CGSB)
 - .1 CAN/CGSB 1.181, Ready-Mixed Organic Zinc-Rich Coating.
- .5 Health Canada/Workplace Hazardous Materials Information System (WHMIS)
 - .1 Material Safety Data Sheets (MSDS).

1.3 System Description

- .1 Performance Requirements:
 - .1 Catalogued or published ratings for manufactured items: obtained from tests carried out by manufacturer or those ordered by manufacturer from independent testing agency signifying adherence to codes and standards in force.
 - .2 Capacity: flow rate, total static pressure, bhp W, efficiency, revolutions per minute, power, model, size, sound power data and as indicated on schedule.
 - .3 Fans: statically and dynamically balanced, constructed in conformity with AMCA 99.
 - .4 Sound ratings: comply with AMCA 301, tested to AMCA 300. Supply unit with AMCA certified sound rating seal.

- .5 Performance ratings: based on tests performed in accordance with ANSI/AMCA 210. Supply unit with AMCA certified rating seal, except for propeller fans smaller than 12" (300 mm) diameter.

1.4 Submittals

- .1 **Product Data:** Submit manufacturer's printed product literature, specifications and datasheet in accordance with Section 01 33 00 - Submittals. Include product characteristics, performance criteria, and limitations.
- .2 Shop Drawings:
 - .1 Submit shop drawings and product data in accordance with Section 01 33 00 - Submittals.
- .3 Provide:
 - .1 Fan performance curves showing point of operation, BHP kW and efficiency.
 - .2 Sound rating data at point of operation.
- .4 Indicate:
 - .1 Motors, sheaves, bearings, shaft details.
 - .2 Minimum performance achievable with variable speed controllers and variable inlet vanes as appropriate.
- .5 **Quality assurance submittals:** Submit following in accordance with Division 1 - General Requirements.
 - .1 Certificates: Submit certificates signed by manufacturer certifying that materials comply with specified performance characteristics and physical properties.
 - .2 Instructions: Submit manufacturer's installation instructions.
 - .1 Contractor shall make available one (1) copy of systems supplier's installation instructions.
- .6 **Closeout Submittals:**
 - .1 Provide operation and maintenance data for incorporation into manual specified in Section 01 78 00 - Contract Completion.

1.5 Maintenance

- .1 Extra Materials:
 - .1 Provide maintenance materials in accordance with Section 01 78 00 - Contract Completion.
 - .1 Spare parts to include:
 - .1 Matched sets of belts.
 - .2 Furnish list of individual manufacturer's recommended spare parts for equipment, include:
 - .1 Bearings and seals.
 - .2 Addresses of suppliers.

- .3 List of specialized tools necessary for adjusting, repairing or replacing.

1.6 Delivery, Storage, & Handling

- .1 **Packing, shipping, handling and unloading:** Deliver, store and handle materials in accordance with Division 1 requirement and manufacturer's written instructions.

PART 2 - PRODUCTS

2.1 Fans General

- .1 Space allocation, motor sizes, base details, connection arrangements and performance based on fan equipment by manufacturers as shown in schedules.
- .2 Fans:
- .1 Labelled with Air Performance, or Sound and Air Performance AMCA Certified Rating Seals
- .2 Of same manufacturer for similar applications but may be chosen from other manufacturers' product lines for other different applications.
- .3 Motors:
- .1 In accordance with Section 20 05 10 supplemented as specified herein.
- .2 For use with variable speed controllers.
- .3 Sizes as specified in schedule.
- .4 **Accessories and hardware:** matched sets of V-belt drives, adjustable slide rail motor bases, belt guards, coupling guards fan inlet and or outlet safety screens as indicated and as specified in Section 20 05 10, inlet outlet dampers and vanes and as indicated.
- .5 Factory primed before assembly in colour standard to manufacturer.
- .6 Fans serving outside air requires protective coating on wheels and internal casing. Apply ADSIL coating.
- .7 Scroll casing drains: as indicated.
- .8 Bearing lubrication systems plus extension lubrication tubes where bearings are not easily accessible.
- .9 **Vibration isolation:** to Section 20 05 20 – Mechanical Vibration Control.
- .10 **Flexible connections:** to Section 23 33 00 – Duct Accessories & Dampers.
- .11 Acceptable manufacturers: Refer to Section 23 34 15.

PART 3 - EXECUTION

3.1 Manufacturer Instructions

- .1 Compliance: comply with manufacturer's written recommendations or specifications, including product technical bulletins, handling, storage and installation instructions, and datasheet.

3.2 Fan Installation

- .1 Comply with manufacturers requirements. Ensure vibration free installation. Leave access for servicing. Install belt guards and weatherproof covers as required.
- .2 Install fans as indicated, complete with resilient mountings specified in Section 20 05 20 – Mechanical Vibration Control, flexible electrical leads and flexible connections in accordance with Section 23 33 00 - Duct Accessories & Dampers.
- .3 Provide sheaves and belts required for final air balance.
- .4 Bearings and extension tubes to be easily accessible.
- .5 Access doors and access panels to be easily accessible.
- .6 Vane axial fans (mounted vertically or horizontally):
 - .1 provide steel support brackets from floor or overhead with vibration isolators at centreline supports on fan Do not place isolators on floor or at overhead attachment point.
 - .2 Install snubbers parallel with fan horizontal longitudinal axis.

3.3 Start-Up, Demonstration and Training

- .1 Refer to Section 20 05 05 - Common Work Results for Mechanical.
- .2 Include for a four-hour on-site operation demonstration and training session. The training is to be a full review of all components including but not limited to a full operation and maintenance demonstration, with abnormal events.

3.4 Co-ordination

- .1 Starter, disconnect and wiring as per the Schedule indicated on drawing.
- .2 Control wiring by Division 25.

3.5 Anchor Bolts & Templates

- .1 Size anchor bolts to withstand seismic acceleration and velocity forces as specified.

3.6 Cleaning

- .1 Proceed in accordance with Section 01 74 00 - Cleaning.
- .2 Upon completion and verification of performance of installation, remove surplus materials, excess materials, rubbish, tools and equipment.

END OF SECTION

PART 1 – GENERAL

1.1 Submittals

- .1 **Shop Drawings/Product Data:** Submit shop drawings/product data sheets for inline fans and accessories. Shop drawings/product data sheets must confirm that the fans conform to requirements of the Contract Documents. Include the following:
 - .1 certified fan performance curves.
 - .2 product data for all accessories.
 - .3 product data for fan motors.
- .2 **Factory Inspection Report:** 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 **Site Inspection and Start-Up Report:** Submit a site inspection and start-up report from the manufacturer's representative as specified in Part 3 of this Section.

1.2 Quality Assurance

- .1 Inline fan manufacturers are to be current members of the Air Movement and Control Association International Inc. (AMCA), and the fans are to be rated (capacity and sound performance) and certified in accordance with requirements of the following standards:
 - .1 ANSI/AMCA Standard 210, Laboratory Method of Testing Fans for Certified Aerodynamic Performance Rating;
 - .2 AMCA Standard 211, Product Rating Manual for Fan Air Performance;
 - .3 ANSI/AMCA Standard 300, Reverberant Room Method for Sound Testing of Fans;
 - .4 AMCA Standard 311, Product Rating Manual for Fan Sound Performance;
 - .5 AMCA Standard 99-2408, Operating Limits for Centrifugal Fans.

PART 2 – PRODUCTS

2.1 Inline Fans

- .1 Centrifugal, ULC listed, AMCA sound and air performance certified bearing the seal, factory run tested inline fans as per the drawing schedule and as follows:
 - .1 a galvanized steel housing with ½" (12 mm) thick acoustic insulation and complete with removable bottom panel, adjustable mounting brackets, and duct connection collars with discharge backdraft damper;
 - .2 a removable motor-fan assembly consisting of a permanently lubricated, vibration isolated motor with power cord and plug connected to an internal terminal box with receptacle and direct connected to a dynamically balanced, forward curved centrifugal fan wheel.
- .2 **Accessories:** 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 smoke developed/flame spread requirements of 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;

2.2 Acceptable Manufacturers: Acceptable centrifugal inline fan manufacturers are:

- .1 Penn Barry.
- .2 Twin City Fan and Blower;
- .3 Loren Cook Co.;
- .4 Greenheck Fan Corp.;
- .5 Jenco Fan;
- .6 Carnes Company Inc.

PART 3 – EXECUTION

3.1 Installation Of Centrifugal Inline Fans

- .1 Provide inline centrifugal fans where shown.
- .2 Secure each fan in place from the structure with vibration isolation, independent of connecting ductwork and in accordance with the fan manufacturer's published instructions.
- .3 Ensure that duct connections are made using flexible connection material.
- .4 **Equipment and System Manufacturer's Certification:** Refer to the article entitled Equipment and System Manufacturer's Certification in the mechanical work Section entitled Mechanical Work General Instructions.
- .5 **Start-Up:** Refer to the article entitled Equipment and System Start-up in the mechanical work Section entitled Mechanical Work General Instructions.
- .6 **Demonstration and Training:** Refer to the article entitled Equipment and System O&M Demonstration & Training in the mechanical work Section entitled Mechanical Work General Instructions. Include for a four hour on-site operation demonstration and training session. The 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

PART 1 - GENERAL

1.1 Submittals

- .1 **Shop Drawings/Product Data:** Submit shop drawings/product data sheets for air terminals. Shop drawings/product data sheets must confirm that the proposed air terminals conform to requirements of the Contract Documents. Include the 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 **Test Report:** Submit with shop drawings/product data, a test report in accordance with ANSI/AMCA Standard 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) as per ISO 3741 for the second through seventh octave bands, and confirmation that pressure loss through a silencer will not exceed 60% of inlet velocity pressure maximum.
- .3 **Site Inspection and Start-Up Report:** Submit a site inspection and start-up report from the 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 the Air-Conditioning, Heating and Refrigeration Institute (AHRI), and the terminals are to be in accordance with requirements of the following standards:
 - .1 AHRI Standard 880, Performance Rating for Air Terminals;
 - .2 ANSI/AMCA Standard 210, Laboratory Method of Testing Fans for Certified Aerodynamic Performance Rating;
 - .3 International Organization of Standardization (ISO) Standard IS) 3741, Acoustics-Determination of Sound Power Levels of Noise Sources Using Sound Pressure-Precision Methods for Reverberation Rooms.
- .2 Acceptable manufacturers are:
 - .1 Price Industries Inc.;
 - .2 MetalAire;
 - .3 Titus;
 - .4 Nailor Industries Inc.;
 - .5 Krueger Division of Air System Components Inc.

PART 2 - PRODUCTS

2.1 Variable Air Volume Terminal Boxes

- .1 Single duct, controller type, pressure independent variable air volume boxes as per the drawing schedule and/or the floor plans, each individually field adjustable to minimum and maximum air volumes. Terminal box sound power levels with an attenuator or lined discharge duct in place are not to exceed sound power levels, in decibels, of 61, 53, 48, 44, 42 and 41 in octave bands 2 to 7 respectively at specified air quantities and 370 kPa (55 psi) entering static pressure. Each box is to be complete with:
 - .1 **housing:** #22 gauge galvanized steel, sealed and gasketed, internally lined with hospital grade 25 mm (1") thick fibre free foam insulation meeting NFPA 90A and CAN/ULC-S102 flame spread and smoke developed requirements, and complete with:
 - .1 exposed cut edges of the liner material factory coated with NFPA 90A and CAN/ULC-S102 approved sealant;
 - .2 a 50 mm (2") long, round inlet duct connection;
 - .3 a rectangular discharge opening with slip and drive cleat duct connection facilities;
 - .4 a protective galvanized steel shroud for the controller and damper actuator .
 - .2 **air valve damper:** normally open, galvanized steel blade with peripheral gasket, pivoting in self-lubricating bearings and with air leakage past a closed damper of 2% or less of rated capacity at 750 Pa (3" wc) inlet static pressure;
 - .3 **air flow sensor:** located at the box inlet, complete with gauge taps, multiple pressure sensing ports, and an averaging chamber designed to accurately average the flow across the inlet of the box with an accuracy of within 5% with a 90° sheet metal elbow located directly at the inlet, and amplify the sensed air flow signal;
 - .4 **controller/actuator:** supplied as part of the controls work specified in mechanical work Automatic Controls Section, shipped to the box manufacturer's plant by the controls supplier, and factory installed, connected, tested, calibrated and set by the box manufacturer;
 - .5 for boxes as scheduled, AHRI performance rated and certified, CSA certified electric reheat coils in accordance with drawing schedule, each factory mounted, wired and tested and complete with:
 - .1 galvanized steel coil frame and cabinet with 20 mm (¾") thick neoprene coated glass fibre insulation meeting NFPA 90A and 25/50 flame spread/smoke developed ratings when tested in accordance with CAN/ULC S102;
 - .2 hinged access door for electrical enclosure;
 - .3 low watt density coil consisting of minimum Grade 80/20 nickel-chromium wire elements insulated from frame by floating ceramic bushings;
 - .4 pre-wired safety devices and controls including:

- .1 automatic reset primary thermal cut-out and a manual reset secondary thermal cut-out;
 - .2 differential pressure switch to shut-down coil upon sensing a no air flow condition;
 - .3 electronic modulating controller compatible with building controls for proportioned pulsed AC or DC control of heater;
 - .4 door interlock disconnect switch;
 - .5 mercury contactors;
 - .6 Class II, 24 volt AC control transformer as required.
- .6 **attenuators:** galvanized steel attenuators, lined as per box housings, each factory supplied loose and with a length as per the drawing schedule;
- .2 Terminal box sound power levels with an attenuator or lined discharge duct in place are not to exceed sound power levels, in decibels, of 61, 53, 48, 44, 42 and 41 in octave bands 2 to 7 respectively at specified air quantities and 370 kPa (55 psi) entering static pressure.

PART 3 - EXECUTION

3.1 Installation of Terminal Boxes

- .1 Provide ceiling mounted terminal boxes where shown.
- .2 Secure each box in place from the structure by means of galvanized steel angles and hanger rods, independent of connecting ductwork.
- .3 Connect each box with ductwork as indicated. Provide straight inlet duct the same size as the box inlet and of a length equal to a minimum of four duct diameters. Refer to the drawing detail. Co-ordinate final box adjustments and settings with personnel doing system testing and balancing work.
- .4 **Start-Up:** Refer to the Section entitled Common Work Results for Mechanical.
- .5 **Demonstration and Training:** Refer to Section entitled Common Work Results for Mechanical. Include for a one-half day on-site operation demonstration and training session. The 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 **Shop Drawings/Product Data:** Submit shop drawings/product data sheets for grilles and diffusers. Shop drawings/product data is to include capacity, throw and terminal velocity, noise criteria, pressure drops, and all other data to confirm that the products proposed meet all requirements of the Contract Documents.
- .2 **Damper Adjustment Keys:** Supply and hand to the Owner at Substantial Performance, a minimum of ten identified (with tags) grille/diffuser volume control damper adjustment keys.
- .3 **Colour Chart(s):** Submit manufacturer's colour chart(s) for all grilles and diffusers for which a finish colour is to be selected.
- .4 **Fan Filter Diffuser Site Inspection and Start-Up Report:** Submit a site inspection and start-up report from the fan filter diffuser manufacturer's representative as specified in Part 3 of this Section.

1.2 Quality Assurance

- .1 Grilles and diffusers are to be tested and performance certified to the Air-Conditioning and Refrigeration Institute Standard ARI 650, Standard for Air Outlets and Inlets.
- .2 Acceptable manufacturers are:
 - .1 Price Industries Inc.;
 - .2 MetalAire;
 - .3 Krueger Division of Air System Components Inc.;
 - .4 Titus;
 - .5 Nailor Industries Inc.;
 - .6 Tuttle & Bailey.

PART 2 - PRODUCTS

2.1 Grilles and Diffusers

- .1 Grilles and diffusers of the type, size, capacity, finish, and arrangement as shown on the drawings and as per the drawing schedule, each equipped with all required mounting and connection accessories to suit the mounting location and application.
 - .1 **mounting gasket:** roll type gasket material supplied with the units for site installation on T-bar ceiling members;

PART 3 - EXECUTION

3.1 Installation of Grilles and Diffusers

- .1 Provide grilles and diffusers where shown on the drawings. Wherever possible, grilles and diffusers are to be the product of one 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 the final architectural reflected ceiling plans and detailed wall elevations, and to conform to the final lighting arrangement, ceiling layout, ornamental and other wall treatment.
- .4 Equip supply diffusers having a basic four-way or all-round air pattern for operation in one, two, or three way pattern where indicated on the drawings.
- .5 Attach troffer type diffusers associated with typical ceiling mounted fluorescent lighting fixtures to the fixtures on the floor prior to fixture installation in the ceiling. When fixtures are installed, connect diffuser boots with flexible ductwork.
- .6 Provide sheet metal plenums, constructed of the same material as the connecting duct, for linear grilles and/or diffusers where shown. Construct and install the 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 the duct connection collar(s) with volume control device(s).
- .7 Where linear type diffusers/grilles are installed in suspended T-bar ceilings, clip the diffusers/grilles in place using clip supplied by the diffuser/grille manufacturer.
- .8 Confirm grille and diffuser finishes prior to ordering.

END OF SECTION

PART 1 – GENERAL

1.1 Submittals

- .1 **Shop Drawings/Product Data:** Submit shop drawings/product data for all units to confirm compliance with requirements of the Contract Documents. Include:
 - .1 certified fan performance curves.
 - .2 estimated sound power levels to be expected across individual octave bands in Db.
 - .3 certified power and control wiring diagrams which differentiate between factory and site wiring.
 - .4 dimensioned layouts, including dimensioned curb layouts and duct penetrations, as applicable.
 - .5 product data for fan motors and drives.
 - .6 all items shipped loose for site installation.
- .2 **Factory Inspection and Test Report:** Submit with delivery of each unit a copy of the factory inspection and fire test report and include a copy of each report with O & M Manual project close-out data.
- .3 **Site Inspection and Start-Up Report:** Submit a site inspection and start-up report from the manufacturer's representative as specified in Part 3 of this Section.
- .4 **Spare Air Filters:** Submit spare air filters as specified in Part 2 of this Section.
- .5 **Roof Opening Coordination:** Supply reviewed copies of curb assembly shop drawings or product data sheets to the trade who will cut the roof openings for ductwork, and ensure that the openings are properly sized and located.
- .6 **Extended Warranties:** Submit signed copies of the manufacturer's extended warranties as follows:
 - .1 stainless steel gas fired unit heat exchanger: ten years;
 - .2 refrigerant compressor(s): five years;
 - .3 integrated modular control: three years.

1.2 Quality Assurance

- .1 Heating and air conditioning equipment is to be rated (capacity, performance, efficiency and sound) and certified in accordance with requirements of the following Air-Conditioning and Refrigeration Institute Standards:
 - .1 ARI 210/240, Performance Rating of Unitary Air-Conditioning and Air-Source Heat Pump Equipment;
 - .2 ARI 270, Sound Rating of Outdoor Unitary Equipment;

- .3 ARI 340/360, Commercial and Industrial Unitary Air-Conditioning and Heat Pump Equipment.
- .2 Heating and air conditioning equipment is also to be in accordance with requirement of the following Codes, Standards, and Regulations:
 - .1 CSA B52, Mechanical Refrigeration Code;
 - .2 CAN/CSA-C22.2 No. 236/UL 1995, Heating and Cooling Units;
 - .3 ANSI/ASHRAE 90.1, Energy Standard for Buildings Except Low Rise Residential Buildings;
 - .4 CSA or ETL certification and labelling for all electrical components;
 - .5 governing local Codes and Regulations.
- .3 Acceptable manufacturers are:
 - .1 Annexair Inc.
 - .2 Haakon
 - .3 Daikin Industries Ltd.;
 - .4 Or Approved Equal

PART 2 – PRODUCTS

2.1 Air Handling Units – Packaged Outdoor

- .1 Thermo-Composite Panels (with thermal break frame)
 - .1 The unit housing shall be no-through metal with 2” Thermo-Composite and foam panel construction - interior and exterior, or an all-aluminum 4” Foam thermal break construction - interior and exterior. Thermal break construction using a gasket to insulate two panels is not an acceptable equivalent to a no-through metal constructed casing. No-through metal construction will be inherent to all the component construction in the assembly.
 - .2 The unit housing shall be constructed from a frame, base and panel assembly. Unit shall be completely factory assembled and shipped in one piece as shown on drawings.
 - .3 Base structure shall be fully welded G-90, protected weatherized exterior, and have integral lifting lugs which can be removed once the unit is installed.
 - .4 The frame shall consist of anodized extruded aluminum profiles which incorporates a thermally broken construction; welded together for reinforcement and insulated for superior thermal performance.

-
- .5 All panels and access doors shall be double wall construction with and insulated with a High- Performance 2" GREEN foam insulation that is made from 100% recycled content, produced in an eco-friendly manner without using CFCs or HCFCs. The U-value of the sandwich panel shall be 0.0714 (R-14 minimum) . Any insulation incorporating CFCs or HCFCs in its construction is strictly prohibited from this application.
 - .6 Thermo-Composite panels shall be provided for the entire unit construction, including but not limited to, walls, doors, floors, roof, interior partitions, and electrical compartment. Panels shall be non-load bearing type.
 - .7 Unit casing will have no exterior condensation at interior AHU temperatures down to 42.5F while unit exterior conditions are maintained at 95 F dry bulb / 85 F wet bulb. The air handling unit manufacturer shall submit a copy of the test report demonstrating the general construction of the unit housing thermal performance. The test shall include placing the housing panels in a climate chamber and exposing the unit to the conditions mentioned previously. If the manufacturer does not have access to a Climate Chamber such equipment, an independent testing agent must be hired to transport the test unit to a qualified test facility and perform the test at the expense of the manufacturer. Inability to provide this option to the engineer will make the manufacturer ineligible to bid on this project.
 - .8 The housing shall be rated in accordance with SMACNA and ASHRAE 111 to have a deflection of no more than L/240 at 8" (CD2) and 1% leakage rate at 8" positive pressure and meet AHRI 1350 Casing Air Leakage rating Class 6, for one piece construction.
 - .9 Fire resistance of the panel will be in compliance with UL 94 rated at 5VA; and a flame spread / smoke development in compliance with UL 723 ASTM E84 Class 1 rating.
 - .10 All roof and side wall seams shall be positively sealed to prevent water and air leakage. The OA compartment shall have 1" SCH 40 PVC drains extended to exterior of unit (outdoor units only).
 - .11 Floor duct openings shall be covered with 1" Fibreglass Molded safety walk-on grating.
 - .12 Access doors shall be provided to all major components to facilitate quick and easy access. Access doors will be made from the same material as the unit casing and shall incorporate thermal break construction. Fan access door(s) shall have Allegis type handles, with one handle interlinking multiple latches (Door heights up to 59") and threaded insert fastening handles for all remaining doors. Access doors above 59" will have multiple handles. If access doors do not open against unit operating pressure, provide safety latches that allow access doors to partially open after first handle movement and fully open after second handle movement. Hinges shall be Nylon hinge type designed to open 180 degrees. Removable panels provided for equipment pull, as indicated on drawings, shall have key tooled threaded insert fasteners.

-
- .13 Unit shall have the entire exterior finished with a PVDF coating designed for UV resistance. Panels shall be painted Annexair color Pantone Cool Gray 1C. Panels shall pass ASTM B117 3000-hour salt fog resistance test and ASTM D4585 3000-hour moisture condensation resistance test. In addition, paint must meet AAMA 620-02 standard for color, chalking, gloss retention, and abrasion resistance.
 - .14 Outdoor units shall have a rain gutter above each access door and a watertight roof shall be provided with a white TPO UV-reflective membrane. Indoor units do not have the TPO membrane.
 - .15 The air handler unit housing shall be provided with a limited lifetime warranty against corrosion under normal use. A certificate defining the conditions of this warranty shall be available upon request.
- .2 Weather Hoods
- .1 The outdoor intake weather hood shall be completely constructed in aluminum for superior corrosion resistance. The hood shall ship loose for field installation by the installing contractor. Painted galvanized hoods shall not be acceptable due to its susceptibility to corrosion. The outdoor air hood shall be designed with a 4" extruded aluminum louver, bird screen and a plenum enclosure with drain holes. The louver blades shall be drainable type with a maximum 40 degree angle with integral rain baffle. The louver design shall not allow more than 0.01 oz/ft² water penetration when tested in accordance to AMCA 500. The pressure drop of the complete hood assembly shall not exceed 0.1"wc at a maximum 500 fpm face velocity.
- .3 Exhaust Air Louver
- .1 The exhaust air outlet louvers shall be 2" extruded aluminum , with non-restricting blade design and bird screen.
- .4 Heat Recovery Heat Pipe
- .1 Straight Heat Pipe
 - .1 The Heat Pipes shall be inside and integral to the equipment cabinet in a vertical plane or horizontal plane.
 - .2 The tubes shall be ½" OD copper, of specific design for Heat Pipe application, permanently expanded onto the fin collar to form a firm, rigid, and complete pressure contact at all operating conditions. Aluminum tubes will not be allowed.
 - .3 The fin surface shall be continuous plate type Aluminum fins of specific design to produce maximum heat transfer effectiveness for Heat Pipe applications. Airside pressure loss shall be as given on the schedule or otherwise specified. Fin density and the number of rows of tubes shall be as specified.

- .4 Heat transfer fluid shall be selected on the basis of operating temperature and compatibility with tube material and shall be classified as Safety Group A1 in ASHRAE Std 34-2013.
- .5 Heat Pipe capacities, entering and leaving dry and wet bulb temperatures and face velocity shall be as specified.
- .6 The frames and mounting structure shall be minimum 16 gauge galvanized steel.
- .7 The supply and exhaust air streams shall be isolated from each other by a single separating partition, a double separating partition, or a foam filled double separating partition. Cross contamination between the air streams is not acceptable.
- .8 Heat Pipe interconnecting piping and circuitry shall be as specified by the supplier. Each circuit shall be individually processed, charged, and hermetically sealed.
- .9 Working fluid to be R-454B refrigerant, with tubes individually processed, charged and factory tested for leakage.
- .10 The Heat Pipe assembly will be tested and certified to ARI 1060. HPT heat pipes are performance certified to AHRI Std. 1060 and ETL listed to UL Std. 207 and CSA Std. C22.2#140.3. Documents showing testing in accordance with AHRI 1060 but not certified by AHRI will not be acceptable. Tests shall show zero EATR (Exhaust Air Transfer Ratio) from exhaust to supply air.
- .11 The Heat Pipe shall have a five-year limited warranty.

.5 Fans

.1 Plug Fans (EC-Spider with PM Motor)

- .1 Fans shall be direct drive with non-obstructive air intake and externally mounted motor. Fans shall be compact, optimized and construction made of aluminum with 7-blade airfoil geometry protected by an epoxy powder coating.
- .2 To reduce vibration, the impeller shall be balanced to an admissible vibration severity of less than 3.8 mm/s (0.15in/s). Tests shall be made according to ANSI/AMCA Standard 204-05 Fan Application Category for balance and vibration: HVAC BV-3, Balance Quality Grade for rigid Rotors / Impeller: G6.3.
- .3 The fan and motor assembly shall be directly wall mounted without isolation.
- .4 Each fan shall be operated by one controller for speed and airflow regulation.
- .5 High effectiveness (IE5+) permanent magnet motors shall have up to 95% efficiency(+controller) with low noise, low vibration output, compact design, longer life, increased torque at start, reduced heat losses and reduced friction between components.
- .6 The fan shall be able to operate between -40F and +120F ambient temperature.

-
- .7 Motor dust and humidity protection should be IP54 (NEMA 3R) or higher.
 - .8 Motor shall be equipped with thermoset material rotor insulation to eliminate bearing currents.
- .6 Sound Attenuation in Fan Compartment
- .1 The fan section plenum shall include an additional perforated 1" panel, aluminum 14 gauge 3/32" dia x 3/16" c/c perforated 23%. The acoustical insulation shall be Micromat 24 or equal, which does not support fungi or vermin growth. The perforated panel shall be installed on walls and/or ceiling, where applicable.
- .7 EC-Spider Fan Controller
- .1 Speed controller shall be installed as shown on drawings with contactors, relays, and all specified accessories.
 - .2 The speed controller shall be capable of controlling an IPM (Internal Permanent Magnet) motor to 400Hz. An auto-tuning system shall provide the ability to drive any IPM motors.
 - .3 The controller assembly shall be minimum IP65 (NEMA4X) rated and be suitable to be used in the unit airflow.
 - .4 Fan controller shall be designed for continuous operation from -40°F to 122°F (-40°C to +50°C).
 - .5 Fan controller efficiency shall be up to 97%.
 - .6 Fan controller shall come standard with over voltage protection, current and temperature overload protection as well as short-circuit between phases protection.
 - .7 Each fan controller shall be installed on its fan assembly.
 - .8 Fan controller shall be compatible with Modbus RTU RS485 as well as BACnet MS/TP communication protocols.
 - .9 The speed controller includes 3 sets of user adjustable skip frequencies and choice of 0-5Vdc, 0- 10Vdc or 4-20mA speed reference for input and output.
 - .10 The speed controller shall incorporate a dedicated USB port for programming.
 - .11 The speed controller shall have momentary power-loss ride-thru capability.
 - .12 Controller bypass shall not be allowed (N+1 or N-1 redundancy to be used for critical applications).
 - .13 Fan controller shall have a fully integrated EMC filter (meets emissions and immunity norms EN61800-3 (C1 and C2)).
 - .14 Fan controller to be UL60335-2-40, UL61800-5-1, UL61800-5-2 and CS22.2.174 recognized.
- .8 Filters (Dafco Filtration Group)
- .1 Pre-Filters

-
- .1 Filters shall be factory installed where shown on the drawings.
 - .2 The filters shall be Filtration Group Series 400, MERV 10.
 - .3 Media shall be 100% synthetic, mechanical media that does not support microbial growth.
 - .4 Frame shall be a heavy duty, high strength, moisture resistant paperboard with a cross member design that increases filter rigidity and prevents breaching. Frame shall be recyclable.
 - .5 Filters shall have an expanded metal support grid bonded to the air-exiting side of the filter to maintain pleat uniformity and prevent fluttering. Metal support grid shall be recyclable.
 - .6 MERV 10 model High Capacity Serie 400 filters are classified to UL 900 and tested in accordance with the ASHRAE test 52.2.
 - .7 Filter shall have a low initial pressure drop that shall not exceed 0.17" w.g. in 2" at 500 fpm air flow, and 0.11" in 4" at 500 fpm air flow. Filters shall have a recommended final resistance of 1.0" w.g.
 - .8 Filters shall be rated to withstand a continuous operating temperature up to 200°F.
 - .9 Filters shall be placed in a completely sealed, galvanized steel (Std) holding rack with quick release latches for easy replacement.
- .2 Final Filters
- .1 Filters shall be factory installed where shown on the drawings.
 - .2 The air filters shall be Filtration Group Rigid Cell MERV 13 .
 - .3 Media shall be synthetic that does not support microbial growth.
 - .4 Media shall be adhered to a metal grid to reduce fluttering during use and to plastic separators designed to maintain filter configuration during life.
 - .5 Media shall be bonded to frame on all sides eliminating by-pass.
 - .6 Rigid Cell filters are classified to UL 900 and tested in accordance with the ASHRAE test 52.2.
 - .7 Filter shall have a low initial pressure drop that shall not exceed 0.42" w.g. in 12" at 500 fpm airflow for MERV 13. Filters shall have a recommended final resistance of 1.5" w.g.
 - .8 Filters shall be rated to withstand a continuous operating temperature up to 180°F.
 - .9 Filter frame shall be made of 26 ga. Galvanized steel.
 - .10 Filters shall be placed in a completely sealed, galvanized steel (Std) holding rack with quick release latches for easy replacement.
- .9 Dampers
- .1 Air Foil Control Damper (TAMCO Series 1000)

- .1 Dampers shall be installed where shown on the drawings.
- .2 Dampers shall be low leak type (Leakage Class 1A at 1 in. w.g. (0.25 kPa) static pressure differential).
- .3 Blades are maximum 6" deep extruded aluminum air-foil profiles. All blades are symmetrically pivoted. Galvanized dampers will not be acceptable.
- .4 Blade seals are extruded EPDM. Frame seals are extruded silicone. Seals are secured in an integral slot within the aluminum extrusions. Blade and frame seals are mechanically fastened to prevent shrinkage and movement over the life of the damper.
- .5 Dampers shall be opposed blade type and installed in the compartments (as shown on the drawings) with linkage rod for actuators, unless otherwise noted.
- .6 Actuators shall be 24V factory installed.
- .7 All actuators shall have spring return mechanism and auxiliary switches. Dampers will be installed in the failed close positions unless otherwise noted.

.10 A2L Refrigerant Mitigation

- .1 Mitigation actions shall start if a concentration level of A2L refrigerant above 12% is detected anywhere in the unit.
- .2 Sensors shall be placed in all sections where potential leak points are present (brazed connections).
- .3 Once activated, mitigation shall perform the following actions:
 - .1 The compressors shall be stopped.
 - .2 All fans shall be started to achieve Qmin (minimum CFM per UL60335-2-40).
 - .3 All unit dampers including OA, RA, EA, bypass and recirculation shall be opened to allow the fastest dilution.
 - .4 Relays to be provided as signals to: Open all zone dampers, activate shut-off valves for partial units, trigger alarms.
- .4 Units shall resume its operation 5 minutes after the concentrations are below the 12% threshold.
- .5 Mitigation shall override all other unit operations (including SHIP) except for emergency operations following smoke or fire detection.

.11 Coils

- .1 Water Coils
 - .1 Coils shall be factory installed in the unit.

- .2 Primary surface shall be round seamless (5/8" O.D.) copper tube with 0.018" plain wall thickness staggered in the direction of airflow. Secondary surface shall consist of a minimum 0.006" rippled aluminum plate fins for higher capacity and structural strength. Fins shall have full drawn collars to provide a continuous surface cover over the entire tube for maximum heat transfer. Tubes shall be mechanically expanded into the fins to provide a continuous primary to secondary compression bond over the entire finned length for maximum heat transfer rates.
- .3 Coils shall be circuited for counter-flow heat transfer to provide maximum mean effective temperature difference for maximum heat transfer rates.
- .4 Headers shall have intruded tube holes to provide a large brazing surface for maximum strength and inherent flexibility.
- .5 Casing shall be constructed of continuous galvanized steel.
- .6 Coils shall be submerged in water and tested with a minimum of 315 psi air pressure. Maximum finned coil height shall be 90" and shall not exceed 550 FPM face velocity or as stated in the coil performance data sheet.
- .7 Drain pan shall be provided under water coils. The coil shall sit on 316 stainless steel support rails installed above a 3 sloped 316 stainless steel drain pan sized to prevent condensate carryover per ASHRAE 62.1. Drain pan shall be connected to the outside and extend to 1" SCH 40 PVC connections. Coils finned height greater than 60" or coils that are stacked, shall include intermediate drain pans. Intermediate drain pans shall be 316 stainless steel.
- .8 All coils shall be rated and certified in accordance with AHRI standard 410.

.12 Sound Attenuators - Silencers

- .1 Silencers shall be of the size, configuration, capacity and acoustic performance as scheduled.
- .2 All rectangular silencers shall be constructed with a 22 gauge steel outer casing and 22 gauge perforated G-90 steel.
- .3 Media shall be formaldehyde-free, acoustic quality fiberglass insulation with long, resilient fibers bonded with a thermosetting resin. Fiber glass density and compression shall be as required to insure conformance with laboratory test data. Fiberglass shall be packed with a minimum of 15% compression during silencer assembly. Media shall be resilient such that it will not crumble or break, and conform to irregular surfaces. Media shall not cause or accelerate corrosion of aluminum or steel. Mineral wool or rockwool will not be permitted as a substitute for fiberglass.
- .4 Silencer materials, including acoustic media, polymer liner and acoustical spacer, where required, shall have maximum combustion ratings as noted below when tested in accordance with ASTM E84, NFPA 255 or UL 723.

-
- .5 Silencers shall be constructed in accordance with ASHRAE and SMACNA standards for the pressure and velocity classification specified for the air distribution system in which it is installed. The silencers shall not fail structurally when subjected to a minimum differential air pressure of 8 inches water gauge.
 - .6 All casing seams and joints shall be lockformed and sealed, stitch welded and sealed or continuously welded for leakage resistant construction. The construction method shall be as specified for the duct system in which the silencers are installed. Airtight construction shall be achieved by use of a duct-sealing compound supplied and installed by the contractor at the jobsite.
 - .7 All perforated steel shall be adequately stiffened to insure flatness and form. All spot welds shall be painted.
 - .8 Silencers shall be fabricated under the Quality System Standard ISO 9001 quality management system.
 - .9 Acoustic performance shall include dynamic insertion loss and generated noise for forward flow (air and noise in same direction) or reverse flow (air and noise in opposite direction) in accordance with the project's air distribution system requirements. Dynamic insertion loss shall be within -2 dB of the values listed in the silencer schedule. Silencer generated noise shall be within +3 dB of the values listed in the silencer schedule.
 - .10 All silencer ratings shall be determined in a test facility which provides for airflow in both directions through the test silencer in accordance with the ASTM E-477-13 or the ISO 7235 test standard. The test set-up, procedure and facility shall eliminate all effects due to flanking, directivity, end reflection, standing waves and reverberation room absorption.
 - .11 Silencer pressure drops shall not exceed those listed in the silencer schedule by more than 0.03" w.g. Silencer pressure drop measurements shall be made in accordance with the ASTM E-477-13 or the ISO 7235 test standard. Tests shall be conducted and reported on the identical units for which acoustical data is presented.
- .13 Power and Safety Control
- .1 The power and control center shall be integral to the unit housing and rated equivalent to NEMA 4X.
 - .2 Under no circumstances shall any wiring or parts be field installed. If units show up at the job site without wiring by the manufacturer, the contractor will have to send back units to the manufacturer at the contractors' expense to get them factory wired and re-tested.
 - .3 Panels that are externally mounted to the unit shall not be accepted, regardless of the NEMA rating they may have.
 - .4 Each panel should have a separate access door with an approved locking device.

- .5 All electrical components contained in the panel shall be UL/CSA certified and labeled. The unit shall be complete with VFDs, fuses, relays, phase protection, terminals for main ON/OFF and step-down transformer. All components shall be factory wired for single point power connection by the manufacturer of the unit. A non-fused safety disconnect switch shall be factory installed for ON/OFF servicing. Please refer to electrical wiring diagrams for field power connections.
- .6 An electrical pipe chase for power and control feeding shall be provided next to the control panel.
- .7 The Short Circuit Current Rating (SCCR) is 5 KA (575 V) rms symmetrical, as noted on schedule.
- .8 GFI (120 V/1), lights, and switches shall be factory installed and wired to a common junction box, powered by others (a separate 120V/1 required).
- .9 Each connection point shall be suitable to accommodate one single copper wire.

.14 Humidification Section

- .1 The unit shall have humidification section with factory installed steam distributors. Steam ramp shall be designed for ultra short absorption distance, under six inches.
- .2 Steam ramp design shall comply with specification and scheduled performance of humidifier.
- .3 Stub outs shall be provided on unit for field connection of atmospheric steam piping
- .4 Condensate drain pan shall be provided beneath steam ramp made from welded stainless steel.
- .5 Condensate from distributor manifold shall be piped through AHU base where it can be picked up by installing contractor and piped to building drain.

.15 Air Temperature and Humidification Control Package

- .1 The unit shall be delivered with factory installed control system. Under no circumstances shall control be provided by other than the manufacturer of the equipment. Field installed control package by the ATC will not be acceptable.
- .2 The control system shall consist of a microprocessor, allowing for full monitoring of all the unit equipment. Remote access ports also allow for potential program upgrade, operation log download and unit monitoring.
- .3 Refer to the Sequence of Operation and control schematic for detailed description of control logic and options.
- .4 Refer to control schematic for all field installed control components and control capability to and/or from others.
- .5 Communication Interface Card: The microprocessor shall be capable of communicating with the following protocol language: Bacnet MS/TP RS-485.
- .6 Provide an HMI display, minimum 7", that allows for easy view of unit function and alarms.

.16 Additional Accessories and Unit Features

- .1 Dirty filter switch
- .2 Door interlocking switch (for fan section)
- .3 Magnehelic gauges (Dwyer 2000 model)
- .4 Condensate overflow switch (for drain pans)
- .5 Fan Airflow Monitoring Station Package
 - .1 The unit shall be delivered with factory installed airflow measuring system. The airflow measuring system, consisting of a piezometer ring and transducer, shall be installed on the fan. The package consists of an inlet port on the fan inlet cone connected with flexible tubing to the transducer.

PART 3 – EXECUTION

3.1 Installation Of Air Handling Units – Packaged Outdoor

- .1 Provide outdoor heating and air conditioning units where shown.
- .2 Provide all required rigging and hoisting/moving equipment required to move each unit to the required locations. Do all rigging/hoisting/moving in accordance with the unit manufacturer's directions and details.
- .3 Hand a curb for each roof mounted unit to the roofing trade on the roof for installation and flashing into the roof construction. Secure each unit in place on the roof curb. Provide continuous gasketing around the perimeter of each curb between the curb and the unit mounting frame.
- .4 Install all components shipped loose with the units. Install in accordance with the manufacturer's recommendations. Calibrate all control components requiring field calibration.
- .5 Extend condensate trapped drains using Schedule 40 galvanized steel piping to the roof.
- .6 Provide remote control panels where shown. Confirm exact locations prior to roughing-in. Connect complete with 24 volt control wiring in conduit to the standards of the electrical work and in accordance with the manufacturer's certified wiring diagram.
- .7 Provide thermostats and wall mount on a recessed box where shown. Confirm exact locations prior to roughing-in. Connect complete with 24 volt control wiring in conduit to the standards of the electrical work and the manufacturer's certified wiring diagram. Set-up and program thermostats in accordance with the Owner's requirements.
- .8 Carefully coordinate the installation of each unit with all other trades making connections to the unit, in particular, power, interlock connections, and control connections.

-
- .9 **Equipment and System Manufacturer's Certification:** Refer to the article entitled Equipment and System Manufacturer's Certification in the mechanical work Section entitled Mechanical Work General Instructions.
- .10 **Start-Up:** Refer to the article entitled Equipment and System Start-up in the mechanical work Section entitled Mechanical Work General Instructions.
- .11 **Demonstration and Training:** Refer to the article entitled Equipment and System O&M Demonstration & Training in the mechanical work Section entitled Mechanical Work General Instructions. Include for a one half day on-site operation demonstration and training session. The 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

PART 1 - GENERAL

1.1 Submittals

- .1 **Shop Drawings/Product Data:** Submit shop drawings/product data sheets, complete with control components, and piping and wiring schematics. Shop drawings and product data sheets must confirm that the equipment proposed meets all requirements of the Contract Documents.
- .2 **Start-up and Certification Letter:** Submit a start-up and certification letter from the equipment supplier as specified in Part 3 of this Section.
- .3 **Refrigerant Piping Schematic:** Prepare and submit a schematic layout of refrigerant piping showing all piping components required for satisfactory operation and maintenance of the system(s), including but not limited to pipe sizes, charging valve, isolating valves, sight glasses, strainers, driers, traps, etc. **Note** that the schematic diagram must be reviewed with and approved by the air conditioning equipment supplier prior to submittal to the Consultant.

1.2 Quality Assurance

- .1 **Codes and Regulations:** Split system air conditioning equipment and installation of the equipment are to be in accordance with requirements of the following:
 - .1 all applicable Provincial Codes and Standards;
 - .2 AHRI Standard 210/240, Performance Rating of Unitary Air Conditioning and Air-Source Heat Pumps.
- .2 **Installation Tradesmen:** Split system air conditioning system installation tradesmen are to be journeyman refrigeration mechanics.

PART 2 - PRODUCTS

2.1 Split System Air Conditioning Equipment

- .1 Factory assembled and tested, package type equipment consisting of an indoor evaporator unit and an exterior condensing unit as per the drawing schedule, CSA or ETL listed and labelled, ARI rated and certified and with a minimum system efficiency of 13 SEER.
- .2 **Evaporator:** Wall mounting assembly consisting of a white moulded high-strength plastic cabinet with front access panel, a motorized horizontal vane to automatically direct air flow in a horizontal and downward direction and which closes when fan operation is stopped, motorized vertical vanes controlled remotely, and a mounting plate supplied loose. The evaporator is to be complete with:
 - .1 casing/panel:
 - .1 Unit case shall be manufactured of heavy duty Acrylonitrile Butadiene Styrene (ABS) and High Impact Polystyrene (HIPS) plastic.
 - .2 Unit case shall have a pearl white finish.

-
- .3 The front surface of the unit shall have an architectural curved panel with pearl white finish.
 - .2 cabinet assembly:
 - .1 Unit shall have one supply air outlet and one return air inlet.
 - .2 Unit shall be equipped with factory installed temperature thermistors for
 - .1 Return air;
 - .2 Refrigerant entering coil;
 - .3 Refrigerant leaving coil
 - .3 Unit shall have a built-in control panel to communicate with the outdoor unit.
 - .4 Unit shall have the following functions as standard
 - .1 Self-diagnostic function;
 - .2 Auto restart function;
 - .3 Auto changeover function;
 - .4 Auto clean function;
 - .5 Dehumidifying function;
 - .6 Hot Start;
 - .7 Sleep mode
 - .5 Unit shall be capable of refrigerant piping in 4 different directions.
 - .6 Unit shall be capable of drain piping in 2 different directions.
 - .3 **fan:** double inlet, forward curve fan(s) direct driven by a single four-speed motor and;
 - .4 **filter:** removable and washable return air filter;
 - .5 **coil:** factory pressure tested multi-angled coil of non-ferrous construction with aluminium fins, copper tubes with silver alloy solder joints, and an insulated condensate drain pan sloped to a drain connection for positive drainage.
 - .3 **Condensing Unit:** Factory run tested weatherproof condensing unit equipped with a control board to interface with the indoor unit and perform all necessary operation functions. The unit is to be pre-charged with R-410a refrigerant for a minimum of 21 m (70') of refrigerant tubing, is to be capable of operation at -18°C (0°F) without additional low ambient controls, and with a height difference between the condensing unit and evaporator of 30 m (100'). Each condensing unit is to be complete with:
 - .1 **cabinet:** galvanized steel plate cabinet with an electrostatically applied thermally fused polyester powder finish, and an ABS plastic fan grille;
 - .2 **fan:** draw-through direct driven balanced fan with horizontal air discharge, mounted in front of the coil, arranged to pull air across the coil, and equipped with a raised fan guard;

-
- .3 **condenser coil:** "L" shaped coil with copper tubes and aluminium fins, factory pressure tested, complete with an integral metal guard and refrigerant flow controlled by a linear expansion valve metering orifice controlled by a microprocessor controlled step motor;
 - .4 **compressor:** vibration isolated DC rotary compressor driven by an inverter circuit to dynamically control compressor speed to match the room load, complete with an accumulator, high pressure safety switch, and circuitry to permit a minimal amount of current to be applied to the motor to maintain enough heat during the off cycle to prevent liquid from accumulating.
 - .5 Defrost Operations
 - .1 The outdoor unit shall be capable of auto defrost operation to melt accumulated ice off the outdoor unit heat exchanger. The defrost cycle control shall be based on outdoor ambient temperatures and outdoor unit heat exchanger temperatures.
 - .6 Oil Management
 - .1 The outdoor unit shall have an oil injection mechanism to ensure a consistent film of oil on all moving compressor parts at low speed.
 - .2 The outdoor unit shall have an oil separator to separate oil mixed with the refrigerant gas during compression and return oil to the compressor.
 - .7 Sound Levels
 - .1 The outdoor unit shall have sound levels not exceeding 55 dB(A) tested in an anechoic chamber under ISO1996 standard.
 - .8 Sensors: The outdoor unit shall have:
 - .1 Suction temperature sensor;
 - .2 Discharge temperature sensor;
 - .3 High pressure sensor;
 - .4 Low Pressure sensor;
 - .5 Outdoor temperature sensor;
 - .6 Outdoor unit heat exchanger temperature sensor
 - .4 **Controls:** System controls are to consist of a microprocessor in each indoor and outdoor unit, and an indoor wall mounted controller site connected to the indoor evaporator unit. The system is to be capable of automatic restart after power interruption, and is to have self-diagnostics ability and indication of total compressor run time.
 - .1 **microprocessors:** the indoor unit microprocessor is to be capable of monitoring return air temperature and evaporator coil temperature, receiving and processing commands from the wall mounted controller, providing emergency operation, and controlling the outdoor unit through its microprocessor and interface board;
 - .2 **wall mounted controller:** the controller is to be complete with an integral temperature sensor, is to perform input and output functions necessary to operate the system, and is to be equipped with the following:

-
- .1 a large DOT liquid crystal display to indicate diagnostic codes for both the indoor and outdoor units, compressor run time, a weekly timer with up to 8 pattern settings per day, set temperature, room temperature, refrigerant piping temperatures, compressor operating conditions, and linear expansion valve opening pulses, sub-cooling and discharge super heat;
 - .2 On/Off button, Increase/Decrease Set Temperature buttons, a Cool/Dry/Fan mode selector, a Timer Menu button, a Timer On/Off button, Set Time buttons, a Fan Speed selector, a Vane Position selector, a Louvre Swing button, a Ventilation button, a Test Run button, and a Check Mode button.
- .5 **Acceptable Manufacturers:** Acceptable manufacturers are:
- .1 Daikin
 - .2 Mitsubishi Electric Sales Canada Inc.;
 - .3 LG Electronics Canada Inc.;
 - .4 Fujitsu General America Inc.;
 - .5 Samsung HVAC;
 - .6 Trane Canada Inc.;
 - .7 Carrier Enterprise Canada.

PART 3 - EXECUTION

3.1 Installation Of SPLIT SYSTEM AIR CONDITIONING EQUIPMENT

- .1 Provide split system air conditioning equipment consisting of an exterior condensing unit and an indoor evaporator, where shown.
- .2 Secure the condensing unit in place, level and plumb, on vibration isolation pads on a concrete housekeeping pad.
- .3 Mount the indoor evaporator unit where indicated. Confirm exact location prior to roughing-in.
- .4 Connect the condensing unit and the indoor evaporator with refrigerant piping in accordance with the piping shop drawing schematic. Refer to the mechanical work Section entitled Refrigerant Piping, Valves, and Accessories. Provide any required additional refrigerant.
- .5 Install all loose control components and do all required control wiring (except building automation system connections) between the condensing unit and the evaporator in conduit in accordance with the manufacturer's control wiring schematic and wiring standards of the electrical work.
- .6 **Equipment and System Manufacturer's Certification:** Refer to the article entitled Equipment and System Manufacturer's Certification in the mechanical work Section entitled Mechanical Work General Instructions.
- .7 **Start-Up:** Refer to the article entitled Equipment and System Start-up in the mechanical work Section entitled Mechanical Work General Instructions.

-
- .8 **Demonstration and Training:** Refer to the article entitled Equipment and System O&M Demonstration & Training in the mechanical work Section entitled Mechanical Work General Instructions. Include for four hours of on-site operation demonstration and training session. The training is to be a full review of all components including but not limited to a full operation and maintenance demonstration, with control set-up and abnormal events.

END OF SECTION

PART 1 - GENERAL

1.1 Submittals

- .1 **Shop Drawings/Product Data:** Submit shop drawings/product data sheets for heating coils, including accessories. Shop drawings/product data sheets must confirm that equipment conforms to requirements of the Contract Documents.

PART 2 - PRODUCTS

2.1 Duct Mounted Hydronic Heating Coils

- .1 Hydronic coils as per the drawing schedule, one or two row as indicated, each certified to ANSI/ARI 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 **tubes and fins:** 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 **casing:** flanged galvanized steel casing arranged to prevent air bypass around the 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 Luvata;
 - .3 Daikin Industries Ltd.;
 - .4 Engineered Air;
 - .5 Carrier Enterprise Canada;
 - .6 Direct Coil;
 - .7 Coilmaster.

PART 3 - EXECUTION

3.1 Installation Of Duct Mounted Hydronic Heating Coils

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

END OF SECTION

PART 1 - GENERAL

1.1 Submittals

- .1 **Shop Drawings/Product Data Sheets:** Submit shop drawings/product data sheets for radiation units, including accessories, and any required control wiring schematics. Shop drawings/product data sheets must confirm that the radiation units proposed conform to all requirements of the Contract Documents.
- .2 **Site Inspection and Start-Up Report:** Submit a site inspection and start-up report from the manufacturer's representative as specified in Part 3 of this Section.

PART 2 - PRODUCTS

2.1 Fin-Tube Type Direction Radiation

- .1 Hot water fin-tube type direct radiation units with capacities/lengths as indicated on the drawings.
- .2 **Wall-Fin Convectors:** Wall-fin convectors are to be complete with:
 - .1 **copper-aluminum elements:** consisting of minimum 32 mm (1¼") IPS seamless copper tubing mechanically expanded into and permanently bonded to 110 mm (4½") square plate type aluminum fins;
 - .2 **enclosures:** as indicated on the drawings, each removable and constructed of #16 gauge cold rolled steel, factory cleaned, phosphatized and finished with primer, and equipped with stamped grilles, flush slip joint enclosure to enclosure joints where required, access doors for valve access, and any required enclosure trim such as column to column extension pieces, column enclosures, etc.;
 - .3 **enclosure and element supports:** continuous minimum #20 gauge steel top support wall guard strip prime coated painted as for enclosure and arranged to maintain the top back edge of the enclosure 20 mm (¾") from the face of the wall, enclosure supports with enclosure locks constructed and finished as for wall strip and designed to hook onto the top strip, and steel element support cradles which attach to slots in the wall guard strip;
- .3 **Acceptable manufacturers:** Acceptable manufacturers are:
 - .1 Engineered Air;
 - .2 Modine Manufacturing Co.;
 - .3 Rosemex Inc.;
 - .4 Sigma Corp.;
 - .5 Slant/Fin Ltd.;
 - .6 Zehnder-Rittling.

PART 3 - EXECUTION

3.1 Installation of Fin-Tube Direct Radiation Units

- .1 Provide fin-tube type direct radiation units where shown.

-
- .2 Secure enclosure brackets in place at maximum 900 mm centres and install element supports or cradles. Slope elements to ensure proper water circulating and to eliminate air. Ensure that enclosures are level and plumb. Provide all required enclosure accessories.
 - .3 Connect elements with piping as indicated. Provide radiator type valves in piping at each element or group of series connected elements, shut-off type in the supply piping, balancing type in return piping. Unless otherwise noted or specified, locate valves and accessories inside enclosures or behind trim, and ensure that the valves are accessible.
 - .4 Where two or more heating elements are connected in series, join the elements with piping the full size of the element tubes or use piping sized to the supply pipe size and connect the elements with eccentric fittings.
 - .5 Equip each element or group of series connected elements with a manual air vent installed in an accessible location.

END OF SECTION

PART 1 – GENERAL

1.1 Submittals

- .1 **Shop Drawings/Product Data:** Submit shop drawings/product data sheets for humidifiers, including accessories. Shop drawings/product data sheets must confirm that equipment conforms to requirements of the Contract Documents.
- .2 **Site Inspection and Start-Up Report:** Submit a site inspection and start-up report from the manufacturer's representative as specified in Part 3 of this Section.
- .3 **Factory Inspection Report:** 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.
- .4 **Cabinet Keys and Spare Steam Water Cylinders:** Submit three identified keys for electric/electronic steam humidifier cabinet doors, and a spare steam/water cylinder for each humidifier prior to Substantial Performance.

PART 2 – PRODUCTS

2.1 Electric/Electronic Steam Humidifier

- .1 CSA certified, package type, three phase, 60 Hz, fully automatic electric/electronic steam humidifier as per the drawing schedule, capable of discharging pure steam with no mineral dust carryover, and as follows:
 - .1 Humidifier internal parts including boiling chamber, hydraulic circuit components, electrical components should be easy to access with a unique front door access.
 - .2 Boiling chamber, cover and fittings constructed from series 300 stainless steel.
 - .3 Boiling chamber cylinder provided with thermal insulation. Thermal insulation shall not be able to lose thermal properties when in contact with water.
 - .4 Immersion heaters INCOLOY alloy-sheathed resistance type with bending radius of 1in minimum to reduce stress concentration, with a tube diameter of 0.43in minimum to maximize surface contact area to water and with no more than 70 watts per square inch of watt density.
- .5 Humidifier to have the following safety protection features:
 - .1 Hi-limit temperature switch
 - .2 Electronic continuous water level sensor.
 - .3 Evaporation rate control algorithm.
 - .4 EcoEnerSmart™ water dilution auto adaptable depending on water quality
 - .5 Integrated back flow prevention water hydraulic with no check valve or open fill cup that are prone to overflow
 - .6 Conductive foam detection sensor.

-
- .6 Humidifier shall be able to be supplied with tap or well water or treated water such as softened or reverse osmosis (RO) water without alteration or add-on option.
 - .7 Removal of boiling chamber cylinder for regular cleaning and maintenance shall be done without the need of tools, and without the use of consumable such as gasket or others.
 - .8 Humidifier to provide full modulation using integrated SSR control, without additional option.
 - .9 Humidifier shall include an integrated automatic wasted water drain cooling function ensuring a maximum water drained temperature of 140°F (60°C), without additional option.
 - .10 Automatic drain of humidifier's boiling chamber should be done with a drain pump allowing for fast and efficient partial or complete flush out without being affected by scale with a minimum flow of 6GPM.
 - .11 Humidifier control and user interface to be provided by 7in touch screen and microprocessor with real time operating system and multilingual screens and menus. User interface should include the following:
 - .1 Dashboard screen indicating real time power consumption and log of events, with the 200 last events recorded in non volatile memory
 - .2 Overview screen indicating real time status of all internal sensors and operation of the humidifiers.
 - .3 Control and humidifier setting screens with possible restricted access allowing for the full set-up of the humidifier and control communication including PID adjustments for optimize humidity control of critical applications
 - .4 Ethernet or Wi-Fi settings for remote control through steamOcloud proprietary web server.
 - .5 Easy software upgrade through USB 2.0 connection
 - .12 Supplied with Modbus RTU for secure and easy integration to Building Management System (BMS), as standard and without additional option.
 - .13 Three (3) years warranty.
 - .14 Accessories
 - .1 Air flow proving switch.
 - .2 High limit switch humidistat.
 - .3 Electronic RH% sensor for duct or space.
 - .4 BACnet MSTP remote communication to Building Management System (BMS).
 - .5 P65, equivalent to NEMA 4 type outdoor enclosure made in stainless steel and with anti- freeze and/or heat protections. Complete with uninsulated roof curb (field insulated).

- .6 Steam ramp (steam distribution grid) factory installed in air handling unit.
Steam ramp to have insulated steam distribution tubes and headers in order to reduce condensate generation.
- .2 Acceptable manufacturers are:
 - .1 IER
 - .2 Steamovap.
 - .3 Pure Humidifier.
 - .4 Dri Steam.

PART 3 – EXECUTION

3.1 Installation Of Electric/Electronic Steam Humidifiers

- .1 Provide electric/electronic steam humidifiers where shown.
- .2 Secure each steam generator assembly in place, level, and plumb, in accordance with the manufacturer's instructions.
- .3 Install steam distributor manifold assemblies where shown and secure in place.
Coordinate installation with the sheet metal trade.
- .4 Connect the steam generators and distribution manifolds with steam and condensate hose kits supplied with the humidifiers. Install in accordance with the manufacturer's instructions.
- .5 Install humidistats and pressure differential air flow proving switches and connect with 24-volt control wiring in conduit to the steam generator control panel.
- .6 Supply a spare water/steam cylinder for each unit and three identified keys for each steam generator cabinet and hand to the Consultant at the site prior to Substantial Performance.
- .7 **Equipment Manufacturer's Certification:** Refer to the article entitled Equipment and System Manufacturer's Certification in the mechanical work Section entitled Mechanical Work General Instructions.
- .8 **Start-Up:** Refer to the article entitled Equipment and System Start-up in the mechanical work Section entitled Mechanical Work General Instructions.
- .9 **Demonstration and Training:** Refer to the article entitled Equipment and System O&M Demonstration & Training in the mechanical work Section entitled Mechanical Work General Instructions. Include for a one half day on-site operation demonstration and training session. The 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 When installation is complete, arrange for the humidifier manufacturer to visit the site to supervise start-up, testing and adjusting of each humidifier, including all controls and safeties, and when this work is complete, obtain from the manufacturer and submit a letter stating the humidifiers have been properly installed, started, adjusted, and are in proper operating condition.

END OF SECTION

PART 1 - GENERAL

1.1 Related sections

- .1 The General Conditions of the Contract, Supplementary Conditions, and General Requirements are part of this specification and shall be used in conjunction with this section as part of the contract documents. Consult the above for further instructions pertaining to this work. The Contractor is bound by the provisions of Division 0 and Division 1.
- .2 Refer to the University of Toronto Building Automation Systems – Design Standards and Guidelines (“Design Standard”), Revision 7, dated June 21st, 2020, for additional requirements. The Design Standard can be found at this link (https://www.fs.utoronto.ca/wp-content/uploads/2021/06/UofT_FS_BuildingAutomationSystems_DesignStandard.pdf) . Where there are contradictions between the Design Standard and this Section, the Design Standard requirements shall take precedence.

1.2 Quality assurance

- .1 The product line being proposed for the project must have an installed history of demonstrated satisfactory operation for a length of 3 years since date of final completion in at least 8 installations of comparative size and complexity.
- .2 No beta level or pilot products with less than 3 years field operation are to be used or tested on Campus without approvals.
- .3 These requirements apply to Operator Software, Service Tool Software, Controller resident software, B-BC's, B-AAC's, B-ASC's, SAs.
- .4 Documentation of this requirement with references shall be available upon request.
- .5 All new, retrofit or renovated BAS devices shall meet the most recent BACNET-135 standards and be verifiably BTL listed.

.6 Approved manufacturers:

- .1 Honeywell, Johnson Controls, Siemens.
- .2 Approved product lines for BAS implementations are as follows:

Johnson Controls	Metasys	Supervisory Network Controller
Honeywell	Comfort Point Open	CP-O, CP-IPC, CP400
Siemens	Apogee	PXC Series

JCI Controllers model NAE 55XX are not acceptable.

-
- .7 All field level mounted or embedded controllers must be by an approved manufacturer. Any factory level mounted controllers for products such as rooftop units, boilers, chillers, etc. must follow and meet these Standards fully including open point accessibility, device discoverability, readability, write-ability and shall be able to be modified by U of T independently. Proprietary and non-open or otherwise locked systems will not be allowed.
- .8 **Installer's Qualifications:**
- .1 Firms specializing and experienced in control system installations for not less than 5 years and with experience with proposed DDC technology installation projects with point counts equal to this project and systems of the same complexity and scale as those of the specified project. Experience starts with awarded Final completion of previous projects. Documentation of this requirement with references shall be available upon request.
- .9 **Installer's Experience with the Proposed Product Line:**
- .1 Firms shall be specialized and experienced with the installation of the acceptable manufacturers' product line for not less than 3 years from date of final completion on at least 5 projects with similar size and complexity. Submittals shall document this experience with reference.
- .10 **Installer's Field Coordinator and Sequence Programmer Qualifications:**
- .1 Individual(s) shall specialize in and be experienced with control system installation for not less than 5 years. Proposed field coordinator shall have experience with the installation of the proposed product line for not less than 2 projects of similar size and complexity. Installer shall submit the names of the proposed individual and at least one alternate for each duty. Submittals shall document this experience with references. The proposed individuals must show proof of the following training:
- .1 **Product Line Training:**
- .1 Individuals overseeing the installation and configuration of the proposed product line must provide evidence of the most advanced training offered by the Manufacturer on that product line for installation and configuration.
- .2 **Programming Training:**
- .1 Individuals involved with programming the site-specific sequences shall provide evidence of the most programming training offered by the vendor of the programming application offered by the Manufacturer.
- .11 **Installer's Service Qualifications:**
- .1 The installer must be experienced in control system operation, maintenance and service of the acceptable manufacturers' products. Installer must document a minimum of 5-year history of servicing installations of similar size and complexity. Installer must also document at least a one-year history of servicing the proposed product line.

.12 Installer's Response Time and Proximity:

- .1 Installer must maintain a fully capable service capacity within a 70 km radius of the project site. Service facility shall manage the emergency service dispatches and maintain the inventory of spare parts.
- .2 Emergency response are listed below in this section. Installer must demonstrate the ability to meet the response times.

.13 Installer's Quality Assurance Plan:

- .1 Installer must provide a description of their quality assurance operations from contract award through final delivery. The description shall include organizational responsibilities for each department represented within the execution of this document from installer's to engineers, service technicians and management.

1.3 Codes and standards

- .1 Codes and Standards: Meet requirements of all applicable local standards and codes, except when more detailed or stringent requirements are indicated by the Contract Documents, including requirements of this Section. Electrical shall be installed per Section 26.
 - .1 ASHRAE/ANSI 135-2012 (BACnet) - (System and Unit Level Devices) - Building Controllers and unit level controllers shall conform to the listed version of the BACnet specification in order to improve interoperability with various building system manufacturers' control systems and devices.
 - .2 ASHRAE/ANSI 135-2012 (BACnet) - (Unit Level Devices) - Unit Controllers shall conform to the listed version of the BACnet specification in order to improve interoperability with various building system manufacturers' control systems and devices.

1.4 System performance

- .1 Performance Standards. The BAS system shall conform to the following:
 - .1 Graphic Display. The system shall display a graphic with a minimum of 20 dynamic points. All current data shall be displayed within 10 seconds of the operator's request.
 - .2 Graphic Refresh. The system shall update all dynamic points with current data within 10 seconds.
 - .3 Object Command. The maximum time between the command of a binary object by the operator and the reaction by the device shall be 5 seconds. Analog objects shall start to adjust within 5 seconds.
 - .4 Object Scan. All changes of state and change of analog values shall be transmitted over the high-speed network such that any data used or displayed at a controller or workstation will be current within the prior 10 seconds.
 - .5 Alarm Response Time. The maximum time from when an object goes into alarm to when it is annunciated at the workstation shall not exceed 10 seconds.

- .6 Program Execution Frequency. Custom and standard applications shall be capable of running as often as once every 5 seconds. The Contractor shall be responsible for selecting execution times consistent with the mechanical process under control.
- .7 Programmable Controllers shall be able to execute DDC PID control loops at a selectable frequency from at least once every 5 seconds. The controller shall scan and update the process value and output generated by this calculation at this same frequency.
- .8 Multiple Alarm Annunciations. All workstations on the network shall receive alarms within 5 seconds of each other.
- .9 Reporting Accuracy. Table 1 lists minimum acceptable reporting accuracies for all values reported by the specified system.

.1 Table 1: Reporting Accuracy

Measured Variable	Reported Accuracy
Space Temperature	$\pm 0.25^{\circ}\text{C}$ [$\pm 0.45^{\circ}\text{F}$]
Ducted Air	$\pm 0.25^{\circ}\text{C}$ [$\pm 0.45^{\circ}\text{F}$]
Outside Air	$\pm 0.25^{\circ}\text{C}$ [$\pm 0.45^{\circ}\text{F}$]
Water Temperature	$\pm 0.26^{\circ}\text{C}$ [$\pm 0.47^{\circ}\text{F}$]
Delta -T	$\pm 0.2^{\circ}\text{C}$ [$\pm 0.36^{\circ}\text{F}$] <- 6-inch duct thermistor temp sensor
Relative Humidity	$\pm 3\%$ RH
Water Flow	$\pm 2\%$ of full scale
Air Flow (terminal)	$\pm 5\%$ of reading *Note 1
Air Flow (measuring stations)	$\pm 3\%$ of reading
Air Pressure (ducts)	$\pm 1\%$ of full scale
Air Pressure (space)	$\pm 1\%$ of full scale (Low Pressure Transducer) 41905050 <- Model number
Water Pressure	$\pm 1\%$ of full scale *Note 2
Electrical Power	5% Solid-Core *Note 3
Carbon Monoxide (CO)	± 30 PPM /
Carbon Dioxide (CO ₂)	± 30 PPM +/- 3% reading

Note 1: (10%-100% of scale) (cannot read accurately below 10%)

Note 2: for both absolute and differential pressure

Note 3: * not including utility supplied meters

1.5 Submittal requirements

- .1 Submittal information shall be provided to the Engineer or Owner electronically prior to commencing the project.
- .2 Quantities of items submitted shall be reviewed by the Engineer and Owner. Such review shall not relieve the BAS manufacturer of furnishing quantities required based upon contract documents.

-
- .3 Provide the Engineer and Owner, any additional information or data which is deemed necessary to determine compliance with the specifications or which is deemed valuable in documenting and understanding the system to be installed.
 - .4 Submit the following within 90 days of contract award:
 - .1 A complete bill of materials of equipment to be used indicating quantities, manufacturers and model numbers.
 - .2 A schedule of all control valves including the valve size, pressure drop, model number (including pattern and connections), flow, CV, body pressure rating, and location.
 - .3 A schedule of all control dampers including damper size, pressure drop, manufacturer, and model number.
 - .4 Provide all manufacturers' technical cut sheets for major system components. When technical cut sheets apply to a product series rather than a specific product, the data specifically applicable to the project shall be highlighted or clearly indicated by other means. Include:
 - .1 Building Controllers
 - .2 Custom Application Controllers
 - .3 Application Specific Controllers
 - .4 Operator Workstations
 - .5 Portable Operator Terminals
 - .6 Auxiliary Control Devices
 - .5 Provide proposed Building Automation System architectural diagram depicting various controller types, workstations, device locations, addresses, and communication cable requirements
 - .6 Provide detailed termination drawings showing all required field and factory terminations, as well as terminal tie-ins to DDC controls provided by mechanical equipment manufacturers. Terminal numbers shall be clearly labeled.
 - .7 Provide points list showing all system objects and the proposed English language object names.
 - .8 Provide a sequence of operation for each controlled mechanical system and terminal end devices.
 - .9 Provide a BACnet Protocol Implementation Conformance Statement (PICS) for each BACnet system level device (i.e. Building Controller & Operator Workstations) type. This defines the points list for proper coordination of interoperability with other building systems if applicable for this project.

1.6 Warranty Requirements

- .1 Warrant all work as follows:
 - .1 BAS system labor and materials shall be warranted free from defects for a period of twelve (12) months after final completion acceptance by the Owner. BAS failures during the warranty period shall be adjusted, repaired, or replaced at no charge to the Owner. The BAS manufacturer shall respond to the Owner's request for warranty service within 24 hours of the initiated call and will occur during normal business hours (8AM-5PM).
 - .2 At the end of the final start-up/testing, if equipment and systems are operating satisfactorily to the customer, the customer shall sign certificates certifying that the BAS is operational, and has been tested and accepted in accordance with the terms of this specification. The date of customer acceptance shall be the start of the warranty period.
 - .3 Operator workstation software, project specific software, graphics, database, and firmware updates shall be provided to the customer at no charge during the warranty period. Written authorization by the customer must be granted prior to the installation of these updates.
 - .4 The BAS manufacturer shall provide a web-accessible Users Network for the proposed System and give the Owner free access to question/answer forum, user tips, upgrades, and training schedules for a one year period of time correlating with the warranty period.
- .2 The project's controls contractor shall provide and maintain secure remote access to the facilities Building Automation System (BAS) or other building systems until up to 1 year after substantial completion. Prior to transition from warranty, the building owner will provide and maintain the secured remote access.
- .3 Data Monitoring & Collection Standards
 - .1 The system shall record and store interval data, 24 hours/day, 7 days/week, 365 days/year.
 - .2 Data to be collected for real-time continuous monitoring and collection of whole-building energy meters and sub-meters if the meters have been installed as part of the warranted project.
 - .3 Data to be collected from building automation and control systems sub-meters and sensors data for equipment status, set points, and operational points.
 - .4 Dashboard Web Interface: The dashboard interface shall allow display of energy and building system data in widgets, charts and tracking applications, and be available without requiring users to utilize external, third party tools.
 - .1 The Dashboard Web Interface shall be accessible via a web browser without requiring any "plug-ins" (i.e. JAVA Runtime Environment (JRE), Adobe Flash).

-
- .2 The interface shall support common Internet web browsers at a minimum including: Internet Explorer 10.0+, Firefox 4.0+, Chrome 10.0+, Opera, Safari
 - .3 The interface shall support the following mobile web browsers at a minimum: iOS (iPad/iPhone) V9.1+, Android (Tablet) V4.3+, Android (Phone) V2.3+.
 - .4 Dashboards shall be customizable for each individual or group of users the to modify personal dashboards at any time using a library of widgets specific to the project site.
 - .5 Dashboards should be capable of tracking & displaying summary metrics and status of energy and emissions goals at various levels: floor/area, building, campus, portfolio.
 - .5 Dashboard Widget Builder/Library:
 - .1 BEMS dashboard shall include an object-based widget builder for the creation of custom widgets, as well as a library of off-the-shelf energy widgets to utilize:
 - .1 Users shall modify personal dashboards at any time using a library of widgets specific to the project site or drawing on a vendor-provided library of energy widgets with embedded logic for common energy calculations.
 - .2 Users are allowed to pick and choose which widgets are displayed, and where they are located.
 - .2 Shall provide an object-based widget builder for the creation of custom widgets including:
 - .1 target a specific building or system/equipment
 - .2 configure time periods, parameter values (maximum/minimum), units of measure
 - .3 select display colors
 - .4 preview widgets using target object.

1.7 Dashboard Access Security:

- .1 Each user shall be required to login to the system with a user name and password in order to view, edit, add, or delete data
- .2 User Profiles shall restrict the user to only the objects, applications, and system functions as assigned by the system administrator.
- .3 Each user shall be allowed to change their user password.
- .4 The System Administrator shall be able to manage the security for all other users.
- .5 The system shall include pre-defined "roles" that allow a system administrator to quickly assign permissions to a user.

1.8 System maintenance

- .1 Perform Building Automation System preventative maintenance and support for a period of 1 year (beginning the date of substantial completion). The Automation system shall be connected prior to substantial completion for data collection, trending and analysis.
 - .1 Database back-up
 - .2 Operator coaching (4) hours during the warranty period
 - .3 Building Automation System Technician support (8) hours during the warranty period to diagnose issues remotely through secure remote access.
 - .4 Fault Detection & Diagnostics Analytics shall diagnose performance against expectations for optimal operation and must indicate: most recent failure, count of failures and exceptions throughout building history for a particular point, most dramatic failure or exception for a particular point, first time the exception or failure was generated.
 - .1 Automated tests for building schedules, systems and equipment shall provide evidence of the onset of a problem and provide graphical data that demonstrates a resolution to the problem.
 - .2 The Building Performance Service shall automatically provide a full range of building-specific FDD analytics without the need to utilize third party tools, external to the system in the following areas:
 - .1 Chilled Water Systems/Equipment
 - .2 VAV Air Systems/Equipment
 - .3 Heating Systems/Equipment
 - .4 CV Air Systems/Equipment
 - .5 Terminal Equipment.

1.9 Ownership of proprietary material

- .1 Project specific software and documentation shall become the owner's property upon project completion. This includes the following:
 - .1 Operator Graphic files
 - .2 As-built hardware design drawings
 - .3 Operating & Maintenance Manuals
 - .4 BAS System software database
 - .5 Controller application programming databases
 - .6 Application Specific Controller configuration files

PART 2 - PRODUCTS

2.1 Control System

- .1 **Acceptable BAS Manufacturers:** The BAS specified in this Section is a modular, expandable DDC building automation system as per drawing control diagrams and sequences, and points lists. Acceptable BAS manufacturers are:
 - .1 Siemens Building Technologies Inc.;
 - .2 Johnson Controls Inc.; (JCI Controllers NAE 55XX are not acceptable.)
 - .3 Honeywell

2.2 Materials

- .1 Use new products that the manufacturer is currently manufacturing and that have been installed in a minimum of 50 installations. Do not use this installation as a product test site unless explicitly approved in writing by the owner or the owner's representative. Spare parts shall be available for at least five years after completion of this contract.

2.3 Communication

- .1 Connectivity / Remote Access / Network Security
 - .1 The control contractor shall coordinate with the Owners IT team, verify the proposed system shall meet all network security requirements and any other network configuration information necessary to each control contractor for the purpose of configuring each Area Controller on the network. The controls contractor shall coordinate the IP address for each Area Controller. It shall be the responsibility of the control contractor to coordinate with the owner for network connectivity.
 - .2 Provide the integration device (gateway) to collect the required monitoring points from the facilities BAS. Interface between the cloud storage and BAS shall be via BACnet® IP.
 - .3 Provide and maintain secure remote access to the facilities Building Automation System (BAS) or other building systems. Users accessing service shall not have access to the building owners network. Secure remote access to the BAS shall not require additional software to be installed on the client device (i.e. VPN client). Secure remote access to the BAS shall not require ANY inbound ports on a firewall to be "exposed" or "forwarded".
 - .4 Secure remote access to the BAS shall be available anywhere, anytime, using a compatible client device (PC/tablet/phone)

-
- .2 This project shall be comprised of a high speed Ethernet network utilizing BACnet/IP communications between System Controllers. Each System Controller shall function as a BACnet Router to each unit controller providing a unique BACnet Device ID for all controllers within the system. Communications between System Controllers and sub-networks of Custom Application Controllers and/or Application Specific Controllers shall be as defined below.
 - .1 Each System Controller shall perform communications to a network of Custom Application and Application Specific Controllers using BACnet/MSTP (RS485) as defined by the BACnet standard.

2.4 Controller software

- .1 Furnish the following applications software for building and energy management. All software applications shall reside and run in the system controllers. Editing of applications shall occur at the building operator interface.
 - .1 Scheduling. Provide the capability to schedule each object or group of objects in the system. Each of these schedules shall include the capability for start, stop, optimal start, optimal stop, and night economizer actions. Each schedule may consist of up to [10] events. When a group of objects are scheduled together, provide the capability to define advances and delays for each member. Each schedule shall consist of the following:
 - .1 Weekly Schedule. Provide separate schedules for each day of the week.
 - .2 Exception Schedules. Provide the ability for the operator to designate any day of the year as an exception schedule. This exception schedule shall override the standard schedule for that day. Exception schedules may be defined up to a year in advance. Once an exception schedule is executed it will be discarded and replaced by the standard schedule for that day of the week.
 - .3 Holiday Schedules. Provide the capability for the operator to define up to 99 special or holiday schedules. These schedules may be placed on the scheduling calendar and will be repeated each year. The operator shall be able to define the length of each holiday period.
 - .4 Optimal Start. The scheduling application outlined above shall support an optimal start algorithm. This shall calculate the thermal characteristics of a zone and start the equipment prior to occupancy to achieve the desired space temperature at the specified occupancy time. The algorithm shall calculate separate sets of heating and cooling rates for zones that have been unoccupied for less than and greater than 24 hours. Provide the ability to modify the start algorithm based on outdoor air temperature. Provide an early start limit in minutes to prevent the system from starting before an operator determined time limit.
 - .2 Trend Log Application
 - .1 Trend log data shall be sampled and stored on the System Controller panel and shall be capable of being archived to a BACnet Workstation for longer term storage.

-
- .2 Trend logs shall include interval, start-time, and stop-time.
 - .3 Trend log intervals shall be configurable as frequently as 1 minute and as infrequently as 1 year.
 - .3 Trend Logs
 - .1 The system controller shall create trend logs for defined key performance indicators for each controlled HVAC device and HVAC application.
 - .2 The trend logs shall monitor these parameters for a minimum of 7 days at 15 minute intervals. The automatic trend logs shall be user adjustable.
 - .4 Alarm/Event Log
 - .1 Any object in the system shall be configurable to generate an alarm when transitioning in and out of a normal or fault state.
 - .2 Any object in the system shall allow the alarm limits, warning limits, states, and reactions to be configured for each object in the system.
 - .3 An alarm/event shall be capable of triggering any of the following actions:
 - .1 Route the alarm/event to one or more alarm log
 - .2 The alarm message shall include the name of the alarm location, the device that generated the alarm, and the alarm message itself.
 - .3 Route an e-mail message to an operator(s)
 - .4 Log a data point(s) for a period of time
 - .5 Run a custom control program
 - .5 Point Control. User shall have the option to set the update interval, minimum on/off time, event notification, custom programming on change of events.
 - .6 Timed Override. A standard application shall be utilized to enable/disable temperature control when a user selects on/cancel at the zone sensor, building operator interface, or the local operator display. The amount of time that the override takes precedence will be selectable from the building operator interface.
 - .7 Anti-Short Cycling. All binary output points shall be protected from short cycling

2.5 Building controllers

- .1 There shall be one or more independent, standalone microprocessor based System Controllers to manage the global strategies described in Application and Control Software section.
 - .1 The System Controller shall have sufficient memory to support its operating system, database, and programming requirements.
 - .2 The controller shall provide a USB communications port for connection to a PC.
 - .3 The operating system of the Controller shall manage the input and output communications signals to allow distributed controllers to share real and virtual point information and allow central monitoring and alarms.

-
- .4 All System Controllers shall have a real time clock.
 - .5 Data shall be shared between networked System Controllers.
 - .6 The System Controller shall continually check the status of its processor and memory circuits. If an abnormal operation is detected, the controller shall:
 - .1 Assume a predetermined failure mode.
 - .2 Generate an alarm notification.
 - .3 Create a retrievable file of the state of all applicable memory locations at the time of the failure.
 - .4 Automatically reset the System Controller to return to a normal operating mode.
 - .7 Environment. Controller hardware shall be suitable for the anticipated ambient conditions. Controller used in conditioned ambient shall be mounted in an enclosure, and shall be rated for operation at -40° C to 50° C [-40° F to 122° F].
 - .8 Clock Synchronization.
 - .1 All System Controllers shall be able to synchronize with a NTP server for automatic time synchronization.
 - .2 All System Controllers shall be able to accept a BACnet time synchronization command for automatic time synchronization.
 - .3 All System Controllers shall automatically adjust for daylight savings time if applicable.
 - .9 Serviceability
 - .1 Provide diagnostic LEDs for power, communications, and processor.
 - .2 The System Controller shall have a display on the main board that indicates the current operating mode of the controller.
 - .3 SD card should be provided and used for local backup. If local Backup through SD card or similar device is not available then provide operator workstation with sufficient memory provide scheduled backups of the system. BAS Service provider shall be responsible for BAS Backups during the warranty period.
 - .4 All wiring connections shall be made to field removable, modular terminal connectors.
 - .5 The System controller shall utilize standard DIN mounting methods for installation and replacement.
 - .10 Memory. The System Controller shall maintain all BIOS and programming information indefinitely without power to the System controller.
 - .11 Immunity to power and noise. Controller shall be able to operate at 90% to 110% of nominal voltage rating and shall perform an orderly shut-down below 80% nominal voltage.

-
- .12 BACnet Test Labs (BTL) Listing. Each System Controller shall be listed as a Building Controller (B-BC) by the BACnet Test Labs with a minimum BACnet Protocol Revision of 14.

2.6 Auxillary control devices

- .1 Motorized dampers, unless otherwise specified elsewhere, shall be as follows:
- .1 Damper frames shall be 16 gauge galvanized sheet metal or 1/8" extruded aluminum with reinforced corner bracing.
 - .2 Damper blades shall not exceed 8" in width or 48" in length. Blades are to be suitable for medium velocity performance (2,000 fpm). Blades shall be not less than 16 gauge.
 - .3 Damper shaft bearings shall be as recommended by manufacturer for application.
 - .4 All blade edges and top and bottom of the frame shall be provided with compressible seals. Side seals shall be compressible stainless steel. The blade seals shall provide for a maximum leakage rate of 10 CFM per square foot at 2.5" w.c. differential pressure.
 - .5 All leakage testing and pressure ratings will be based on AMCA Publication 500.
 - .6 Individual damper sections shall not be larger than 48" x 60". Provide a minimum of one damper actuator per section.
- .2 Control dampers shall be parallel for 2 position control and opposed blade for modulating control unless detailed on the drawings..
- .3 Electric damper/valve actuators
- .1 The actuator shall have electronic overload or digital rotation sensing circuitry to prevent damage to the actuator throughout the rotation of the actuator.
 - .2 Where shown, for power-failure/safety applications, an internal mechanical, spring return mechanism shall be built into the actuator housing.
 - .3 All rotary spring return actuators shall be capable of both clockwise or counter clockwise spring return operation. Linear actuators shall spring return to the retracted position.
 - .4 Proportional actuators shall accept a 0-10 VDC or 0-20 ma control signal and provide a 2-10 VDC or 4-20 ma operating range.
 - .5 All non-spring return actuators shall have an external manual gear release to allow manual positioning of the damper when the actuator is not powered. Spring return actuators with more than 60 in-lb. torque capacity shall have a manual crank for this purpose.
 - .6 Actuators shall be provided with a conduit fitting and a minimum 1m electrical cable and shall be pre-wired to eliminate the necessity of opening the actuator housing to make electrical connections.
 - .7 Actuators shall be Underwriters Laboratories Standard 873 listed.

-
- .8 Actuators shall be designed for a minimum of 60,000 full stroke cycles at the actuator's rated torque.
 - .4 Control Valves
 - .1 Close-off (differential) Pressure Rating: Valve actuator and trim shall be furnished to provide the following minimum close-off pressure ratings:
 - .1 Water Valves:
 - .1 Two-way: 150% of total system (pump) head.
 - .2 Three-way: Shall be installed in mixing configuration, 2 in 1 out. In the mixing configuration, actuator shall be rated for 100% of total system (pump) head
 - .2 Steam Valves: 150% of operating (inlet) pressure.
 - .5 Water Valves
 - .1 Body and trim style and materials shall be in accordance with manufacturer's recommendations for design conditions and service shown, with equal percentage ports for modulating service.
 - .2 Sizing Criteria:
 - .1 Two-position service: Line size.
 - .2 Two-way modulating service: Pressure drop shall be equal to twice the pressure drop through heat exchanger (load), 50% of the pressure difference between supply and return mains, or 34.5 kPa (5 psi), whichever is greater. Valve shall not be less than 1 line size smaller than design piping size.
 - .3 Three-way modulating service: Pressure drop equal to twice the pressure drop through the coil exchanger (load), 34.5 kPa (5 psi) maximum. Valve shall not be less than 1 line size smaller than design piping size.
 - .4 Valves DN 15 (1/2 in.) through DN 50 (2 in.) shall be bronze body or cast brass ANSI Class 250, spring-loaded, PTFE packing, quick opening for two-position service. Two-way valves to have replaceable composition disc or stainless steel ball.
 - .5 Valves DN 65 (2 1/2 in.) and larger shall be cast iron ANSI Class 125 with guided plug and PTFE packing.
 - .3 Water valves shall fail in last position unless used for equipment protection application. Equipment protection shall fail in normally open or closed, as scheduled on plans, or as follows:
 - .1 Heating coils in air handlers - normally open
 - .2 Chilled-water control valves - normally open
 - .3 Other applications—as scheduled or as required by sequences of operation

-
- .4 Zone valves shall be sized to meet the control application and they shall maintain their last position in the event of a power failure.
 - .6 Steam Valves
 - .1 Body and trim materials shall be in accordance with manufacturer's recommendations for design conditions and service with linear ports for modulating service. On modulating applications that require line size is above 2", the valves shall be configured in a 1/3,2/3 piping configuration.
 - .2 Sizing Criteria:
 - .1 Two-position service: pressure drop 10% to 20% of inlet psig
 - .2 Modulating service: 100 kPa (15 psig) or less; pressure drop 50% of inlet psig
 - .3 Modulating service: 101 to 350 kPa (16 to 50 psig); pressure drop 50% of inlet psig
 - .4 Modulating service: over 350 kPa (50 psig); pressure drop as scheduled on plans
 - .7 Binary Temperature Devices
 - .1 Low-voltage space thermostat shall be 24 V, bimetal-operated, mercury-switch type, with either adjustable or fixed anticipation heater, concealed setpoint adjustment, 13°C to 30°C (55°F to 85°F) setpoint range, 1°C (2°F) maximum differential, and vented ABS plastic cover.
 - .2 Line-voltage space thermostat shall be bimetal-actuated, open contact type, or bellows-actuated, enclosed, snap-switch type or equivalent solid-state type, with heat anticipator, UL listed for electrical rating, concealed setpoint adjustment, 13°C to 30°C (55°F to 85°F) setpoint range, 1°C (2°F) maximum differential, and vented ABS plastic cover.
 - .3 Low-limit thermostats. Low-limit airstream thermostats shall be UL listed, vapor pressure type, with an element of 6 m (20 ft) minimum length. Element shall respond to the lowest temperature sensed by any 30 cm (1 ft) section. The low-limit thermostat shall be manual reset only.
 - .8 Wired Temperature Sensors
 - .1 Temperature sensors shall be RTD or thermistor.
 - .2 Duct sensors shall be single point or averaging as shown. Averaging sensors shall be a minimum of 1.5 m (5 ft) in length per 1 m² (10 ft²) of duct cross section.
 - .3 Immersion sensors shall be provided with a separable stainless steel well. Pressure rating of well is to be consistent with the system pressure in which it is to be installed. The well must withstand the flow velocities in the pipe.
 - .4 Space sensors shall be equipped with setpoint adjustment, override switch, display, and/or communication port as shown on plans.
 - .5 Provide matched temperature sensors for differential temperature measurement.

.9 Static Pressure Sensors

- .1 Sensor shall have linear output signal. Zero and span shall be field-adjustable.
- .2 Sensor sensing elements shall withstand continuous operating conditions plus or minus 50% greater than calibrated span without damage.
- .3 Water pressure sensor shall have stainless steel diaphragm construction, proof pressure of 150 psi minimum. Sensor shall be complete with 4-20 ma output, required mounting brackets, and block and bleed valves. Mount in location accessible for service.
- .4 Water differential pressure sensor shall have stainless steel diaphragm construction, proof pressure of 150 psi minimum. Over-range limit (DP) and maximum static pressure shall be 3,000 psi. Transmitter shall be complete with 4-20 ma output, required mounting brackets, and five-valve manifold. Mount in a location accessible for service.
- .5 Low-voltage space thermostat shall be 24 V, bimetal-operated, mercury-switch type, with either adjustable or fixed anticipation heater, concealed setpoint adjustment, 13°C to 30°C (55°F to 85°F) setpoint range, 1°C (2°F) maximum differential, and vented ABS plastic cover.
- .6 Line-voltage space thermostat shall be bimetal-actuated, open contact type, or bellows-actuated, enclosed, snap-switch type or equivalent solid-state type, with heat anticipator, UL listed for electrical rating, concealed setpoint adjustment, 13°C to 30°C (55°F to 85°F) setpoint range, 1°C (2°F) maximum differential, and vented ABS plastic cover.

.10 Low Limit Thermostats

- .1 Safety low limit thermostats shall be vapor pressure type with an element 6m [20 ft] minimum length. Element shall respond to the lowest temperature sensed by any one foot section.
- .2 Low limit shall be manual reset only.

.11 Relays

- .1 Control relays shall be UL listed plug-in type with dust cover and LED "energized" indicator. Contact rating, configuration, and coil voltage shall be suitable for application.
- .2 Time delay relays shall be UL listed solidstate plug-in type with adjustable time delay. Delay shall be adjustable $\pm 200\%$ (minimum) from setpoint shown on plans. Contact rating, configuration, and coil voltage shall be suitable for application. Provide NEMA 1 enclosure when not installed in local control panel.

.12 Current Switches

- .1 Current-operated switches shall be self-powered, solid state with adjustable trip current. The switches shall be selected to match the current of the application and output requirements of the DDC system.
- .2 Differential Pressure Type Switches (Air or Water Service)

.3 Shall be UL listed, SPDT snap-acting, pilot duty rated (125 VA minimum), NEMA 1 enclosure, with scale range and differential suitable for intended application or as shown.

.13 Remote Horn/Strobe:

.1 CSA certified, 24 VDC remote horn and strobe unit, Honeywell Analytics Model P2W-P, capable of operating in humidity ranges of 0-100% and temperature ranges of -35°C to 66°C (30°F-150°F), with a horn rating of minimum 72 dBA at 3 m (10') and a strobe light intensity of minimum 40 W and a frequency of one (1) flash per second.

PART 3 - EXECUTION

3.1 Examination

- .1 The Contract Documents shall be thoroughly examined for coordination of control devices, their installation, wiring, and commissioning. Coordinate and review mechanical equipment specifications, locations, and identify any discrepancies, conflicts, or omissions that shall be reported to the Architect/Engineer for resolution before rough-in work is started.
- .2 The BAS manufacturer shall inspect the jobsite in order to verify that control equipment can be installed as required, and any discrepancies, conflicts, or omissions shall be reported to the Architect/Engineer for resolution before rough-in work is started.

3.2 Protection

- .1 The BAS installation contractor shall protect all work and material from damage by their work or personnel, and shall be liable for all damage thus caused.
- .2 The BAS manufacturer shall be responsible for their work and equipment until final inspection, testing, and acceptance. The BAS installing contractor shall protect their work against theft or damage, and shall carefully store material and equipment received on site that is not immediately installed. The Contractor shall close all open ends of work with temporary covers or plugs during storage and construction to prevent entry of foreign objects.

3.3 Coordination

- .1 Site
 - .1 Where the mechanical work will be installed in close proximity to, or will interfere with, work of other trades, the contractor shall assist in working out space conditions to make a satisfactory adjustment. If the contractor installs his/her work before coordinating with other trades, so as to cause any interference with work of other trades, the contractor shall make the necessary changes in his/her work to correct the condition without extra charge.
 - .2 Coordinate and schedule work with all other work in the same area, or with work that is dependent upon other work, to facilitate mutual progress.

.2 Test and Balance

- .1 The contractor shall furnish a single set of all tools necessary to interface to the control system for test and balance purposes.
- .2 The contractor shall provide training in the use of these tools. This training will be planned for a duration of 4 hours.
- .3 In addition, the contractor shall provide a qualified technician to assist in the test and balance process, until the first 20 terminal units are balanced.
- .4 The tools used during the test and balance process shall be returned to the contractor at the completion of the testing and balancing.

.3 Life Safety

- .1 Duct smoke detectors required for air handler shutdown shall be supplied under Division 26 of this specification. The contractor shall interlock smoke detectors to air handlers for shutdown as described in the Sequences of Operation for this project.
- .2 Smoke dampers and actuators required for duct smoke isolation are provided under Division 23. The status contact shall be provided with the smoke damper and actuator assembly. The contractor shall interlock these dampers to the air handlers as described in the Sequences of Operation for this project as applicable.

.4 Coordination with Controls Specified in Other Sections or Divisions. Other sections and/or divisions of this specification include controls and control devices that are to be part of or interfaced to the control system specified in this section. These controls shall be integrated into the system and coordinated by the contractor as follows:

- .1 All communication media and equipment shall be provided as specified in the "Communication" section of this specification.
- .2 Each supplier of a controls product is responsible for the configuration, programming, start-up, and testing of that product to meet the sequences of operation described in this section.
- .3 The Contractor shall coordinate and resolve any incompatibility issues that arise between the control products provided under this section and those provided under other sections or divisions of this specification.

.5 Parts supplied by controls contractor must be turned over to the mechanical contractor for installation. Parts include but are not limited to control valves, dampers, inline devices, thermal devices, thermal wells.

3.4 General workmanship

- .1 Install equipment, piping, wiring/conduit, parallel to building lines (i.e. horizontal, vertical, and parallel to walls) wherever possible.
- .2 Provide sufficient slack and flexible connections to allow for vibration of piping and equipment.

-
- .3 Install all equipment in readily accessible locations as defined by Canadian Electric Code (CEC). Control panels shall be attached to structural walls or properly supported in a free-standing configuration, unless mounted in equipment enclosure specifically designed for that purpose. Panels shall be mounted to allow for unobstructed access for service.
 - .4 Verify integrity of all control wiring to ensure continuity and freedom from shorts and grounds prior to commencing the startup and commissioning procedures.
 - .5 All control device installation and wiring shall comply with Contract Documents, acceptable industry specifications, and industry standards for performance, reliability, and compatibility. Installation and wiring shall be executed in strict adherence to local codes and standard practices referenced in Contract Documents.

3.5 Field quality control

- .1 All work, materials, and equipment shall comply with the rules and regulations of applicable local, state, and federal codes and ordinances as identified in Contract Documents.
- .2 BAS manufacturer shall continually monitor the field installation for building code compliance and quality of workmanship. All visible piping and or wiring runs shall be installed parallel to building lines and properly supported.

3.6 Existing equipment

- .1 Wiring. The contractor may reuse any abandoned control wires. The integrity of the wire and its proper application to the installation is the responsibility of the contractor. The wire shall be properly identified and tested in accordance with this specification. Unused or redundant wiring must be properly identified as such.
- .2 Wiring. Existing control wiring shall be removed and become the property of the contractor, unless specifically noted or shown to be reused.
- .3 Local Control Panels. The contractor may reuse any existing local control panel to locate new equipment. All redundant equipment within these panels must be removed. Panel face cover must be patched to fill all holes caused by removal of unused equipment or replaced with new.
- .4 Local Control Panels. Remove and deliver to owner.
- .5 Local Control Panels. Existing panels shall be removed and become the property of the contractor.
- .6 Unless otherwise directed, the contractor is not responsible for the repairs or replacement of existing energy equipment and systems, valves, dampers, or actuators. Should the contractor find existing equipment that requires maintenance, the engineer is to be notified in writing.
- .7 Temperature Sensor Wells. The contractor may reuse any existing wells in piping for temperature sensors. These wells shall be verified for proper fit of new sensors.

-
- .8 Refer to Section 01 10 00 for planning, scheduling and coordination of construction. The mechanical system must remain in operation between the hours of 6 a.m. and 6 p.m., Monday through Friday or as coordinated with the Owner. No modifications to the system shall cause the mechanical system to be shut down for more than 15 minutes or to fail to maintain space comfort conditions during any such period. Perform cut-over of controls that cannot meet these conditions outside of those hours.
 - .9 The scheduling of fans through existing or temporary time clocks or control system shall be maintained throughout the DDC system installation.
 - .10 Modify existing starter control circuits, if necessary, to provide hand/off/auto control of each starter controlled. If new starter control packages are required, these shall be included as part of this contract.
 - .11 Patch holes and finish to match existing walls.

3.7 Wiring

- .1 BAS installing contractor is responsible for all mechanical interlock wiring, sensor wiring, and control wiring required unless specified to be factory mounted per Division 23. Inclusive of Boiler interlock wiring.
- .2 All control and interlock wiring shall comply with the National, Local Electrical Codes, and Section 26 05 19 of these Contract Document specifications. Where the requirements of this section differ with those in Section 26 05 19, the requirements of this section shall take precedence. This work includes interlock wiring for Division 23 mechanical equipment required for a complete installation. Equipment specified to have factory mounted controllers and device are not include by this division.
- .3 All CEC Class 1 (line voltage) wiring shall be UL Listed in approved raceway according to CEC requirements.
- .4 Where Class 2 wires are in concealed and accessible locations; including ceiling return air plenums, approved cables outside of electrical raceway can be used provided that the following conditions are met:
 - .1 Circuits meet CEC Class 2 (current-limited) requirements. (Low-voltage power circuits shall be sub-fused when required to meet Class 2 current-limit.)
 - .2 All cables shall be UL listed for application (i.e., cables used in ceiling plenums shall be UL listed specifically for that purpose).
- .5 Do not install Class 2 wiring in conduits containing Class 1 wiring. Boxes and panels containing high voltage may not be used for low voltage wiring except for the purpose of interfacing the two via control relays and transformers.
- .6 Where Class 2 wiring is run exposed, wiring shall be run parallel along a surface or perpendicular to it, and bundled, using approved wire ties at no greater than 3 m (10 ft.) intervals. Such bundled cable shall be fastened to the structure, using industry approved fasteners, at 1.5 m (5 ft.) intervals or more often to achieve a neat and workmanlike result.
- .7 All wire-to-device connections shall be made at a terminal blocks or terminal strip. All wire-to-wire connections shall be at a terminal block, or with a crimped connector. All wiring within enclosures shall be neatly bundled and anchored to permit access and prevent restriction to devices and terminals.

-
- .8 Maximum allowable voltage for control wiring shall be 120Vac. If only higher voltages are available for use, the BAS manufacturer shall provide step-down transformers to achieve the desired control voltages.
 - .9 All control wiring shall be installed as continuous lengths, where possible. Any required splices shall be made only within an approved junction box or other approved protective device.
 - .10 Install plenum wiring in sleeves where it passes through walls and floors. Maintain fire rating at all penetrations in accordance with Contract Documents and National and/or Local Codes.
 - .11 Conduit and wire sizing shall be determined by the BAS manufacturer in order to maintain manufacturer's recommendation and meet National and Local Codes.
 - .12 Control and status relays are to be located in pre-fabricated enclosures that meet the application. These relays may also be located within packaged equipment control panel enclosures as coordinated. These relays shall not be located within Class 1 starter enclosures.
 - .13 Follow manufacturer's installation recommendations for all communication and network bus cabling. Network or communication cabling shall be run separately from all control power wiring.
 - .14 Adhere to Division 26 requirements for installation of electrical raceways.
 - .15 BAS manufacturer shall terminate all control and/or interlock wiring and shall maintain updated (as-built) wiring diagrams with terminations identified at the job site.
 - .16 Flexible metal conduits and liquid-tight flexible metal conduits shall not exceed 3' in length and shall be supported at each end. Flexible metal conduit less than 1/2" electrical trade size shall not be used. In areas exposed to moisture, including chiller and boiler rooms, liquid-tight, flexible metal conduits shall be used.

3.8 Communication wiring

- .1 All cabling shall be installed in a neat and workmanlike manner. Follow manufacturer's installation recommendations for all communication cabling.
- .2 Do not install communication wiring in raceway and enclosures containing Class 1 or other Class 2 wiring.
- .3 Maximum pulling, tension, and bend radius for cable installation, as specified by the cable manufacturer shall not be exceeded during installation.
- .4 Contractor shall verify the integrity of the entire network following cable installation. Use appropriate test measures for each particular cable.
- .5 When a cable enters or exits a building, a lightning arrestor must be installed between the line and ground.
- .6 All runs of communication wiring shall be unspliced length when the length is commercially available.
- .7 All communication wiring shall be labeled to indicate origin and destination.

3.9 Installation of sensors

- .1 Sensors required for mechanical equipment operation shall be factory installed and wired as specified in mechanical equipment specifications. BAS manufacturer shall be responsible for coordinating these control devices and ensuring the sequence of operations will be met. Installation and wiring shall be in accordance with the BAS manufacturer's recommendations.
- .2 Sensors that require field mounting shall meet the BAS manufacturer's recommendations and be coordinated with the mechanical equipment they will be associated.
- .3 Mount sensors rigidly and adequately for the environment the sensor will operate.
- .4 Room temperature sensors shall be installed on concealed junction boxes properly supported by the block wall framing. For installation in dry wall ceilings, the low voltage sensor wiring can be installed exposed and must meet applicable National and Local Electrical Codes.
- .5 All wires attached to wall mounted sensors shall be sealed off to prevent air from transmitting in the associated conduit and affecting the room sensor readings.
- .6 Install duct static pressure tap with tube end facing directly down-stream of air flow.
- .7 Install space static pressure sensor with static sensing probe applicable for space installation where applicable.
- .8 Sensors used in mixing plenums, and hot and cold decks shall be of the averaging type. Averaging sensors shall be installed in a serpentine manner horizontally across duct. Each bend shall be supported with a capillary clip.
- .9 All pipe mounted temperature sensors shall be installed in matched thermowells. Install all liquid temperature sensors with heat conducting fluid in thermal wells for adequate thermal conductance.
- .10 Wiring for space sensors shall be concealed in building drywall. EMT conduit is acceptable within mechanical equipment and service rooms.
- .11 Install outdoor air temperature sensors on north wall complete with sun shield at manufacturer's recommended location and coordinated with Engineer.
- .12 Locate remote horn/strobe alarm within Clinic 2 lab space and connect to flammable vapor sensor specified in Section 25 05 01 of the mechanical specifications. Refer to drawings for location of horn/strobe alarm.

3.10 Installation of dampers, control valves and actuators

3.11 Demolition

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

3.12 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 of the Specification and the drawings.
- .2 The control systems are to generally be as indicated on drawing control diagrams and are to have all the elements therein indicated or implied.
- .3 The control diagrams show only the principal components controlling the equipment and systems. Supplement each control system with all relays, transformers, sensors, etc., required to enable each system to perform as specified and to permit proper operation and supervision.

3.13 Supply of Control Air Dampers and Operators

- .1 Unless otherwise specified, supply all required control dampers. Hand the dampers to the sheet metal trade at the site in the location where they are required for installation as part of the sheet metal work. Ensure that each damper is correctly located and mounted.
- .2 Provide linkage and operators for the dampers. Wherever possible locate damper operators so that 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 that dampers located in ductwork other than galvanized steel are constructed of type 316 stainless steel.

3.14 Supply of Automatic Control Valves and Operators

- .1 Unless otherwise specified, supply all required automatic control valves. Hand the valves to the appropriate piping trades at the site in the locations they are required for installation as part of the piping work. Ensure that each valve is properly sized, located and installed.
- .2 Provide an operator for each valve with on/off control for 2 position, 0-10vdc or 4-20ma for modulating for control. Spring return actuators are required on as defined on the drawings for fail safe operation, or as needed to protect the equipment, such as Normal Closed position for outside air dampers.

3.15 Installation of Control System Components

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

3.16 Actuators

- .1 Mount and link multiple control damper actuators where required, per manufacturer's instructions.

-
- .2 To compress seals when spring-return actuators are used on normally closed dampers, power the actuator to approximately 5° open position, manually close the damper, and then tighten the linkage.
 - .3 Check operation of damper/actuator combination to confirm that actuator modulates damper smoothly throughout stroke to both open and closed positions. Coordinate any installation problems with Sheet metal Contractor.
 - .4 Valves - Actuators shall be mounted on valves with adapters approved by both the actuator and valve manufacturer. Actuators and adapters shall be mounted in the factory as an approved design arrangement and shall not be field modified.

3.17 Warning labels

- .1 Permanent warning labels shall be affixed to all equipment that can be automatically started by the BAS system.
- .2 Permanent warning labels shall be affixed to all motor starters and all control panels that are connected to multiple power sources utilizing separate disconnects.

3.18 Identification of hardware and wiring

- .1 All field wiring and cabling, including that within factory mounted, and wired control panels and devices for mechanical equipment, shall be labeled at each end within 2" of termination with a cable identifier and other descriptive information for troubleshooting, maintenance, and service purposes. BAS manufacturer to coordinate this labeling requirement with mechanical equipment manufacturer as it relates to controls.
- .2 Permanently label or code each point of field terminal strips to show the instrument or item served and correlate them to the BAS design drawings.
- .3 Identify control panels with minimum 1-cm letters on laminated plastic nameplates.
- .4 Identifiers shall match record documents. All plug-in components shall be labeled such that removal of the component does not remove the label.

3.19 Controllers

- .1 Provide a separate DDC Controller for individual HVAC mechanical equipment. DDC Controllers shall be factory mounted, installed, and wired by mechanical equipment manufacturer as specified. BAS manufacturer shall furnish and coordinate DDC controllers and control devices and ensure that installation and wiring adhere to BAS manufacturer's design recommendations. For those mechanical equipment units that do not have factory installed controls specified, the BAS manufacturer shall field mount controls and coordinate all installation and termination information to ensure the specified sequence of operations are met.

3.20 Programming

.1 BAS Operator's Interface

- .1 Provide color graphics for each piece of mechanical equipment depicting sufficient I/O to monitor and troubleshoot operation. Additionally, provide individual floor plans of the building allowing an operator to quickly view the overall floor plan area for any out of tolerance conditions that may need addressing. Operator color graphics shall include Chiller Plant, Cooling Tower System, Boiler Plant, Air Handling Units, Rooftop Units, VAV Terminal Boxes, Fan Coil Units, Unit Ventilators, Heat Exchangers, Exhaust Fans, etc. These standard graphics shall depict all points dynamically as specified in the points list and/or indicated in sequence of operation.
- .2 As built drawings shall be linked to the graphics or accessible through the operator interface.
- .3 BAS contractor shall provide a dedicated VAS graphic for all air systems on the project. A sample of all unique graphics shall be included in the engineering submittal. If the advanced sequences are provided, this graphic could quickly allow the engineer to verify:
 - .1 Static Pressure Reset
 - .2 Critical Valve Reset
 - .3 SA Temperature Reset
 - .4 Demand Ventilation
- .4 The BAS manufacturer shall provide all the labor necessary to install, initialize, start-up, and trouble-shoot all operator interface software and their functions as described in this section. This includes any operating system software, the operator interface data base, and any third party software installation and integration required for successful operation of the operator interface.

3.21 Control system checkout and testing

- .1 Start-up testing. All testing in this section shall be performed by the contractor and shall make up part of the necessary verification of an operating control system. This testing shall be completed before the owner's representative is notified of the system demonstration.
 - .1 The contractor shall furnish all labor and test apparatus required to calibrate and prepare for service all of the instruments, controls, and accessory equipment furnished under this specification.
 - .2 Verify that all control wiring is properly connected and free of all shorts and ground faults. Verify that terminations are tight.
 - .3 Enable the control systems and verify calibration of all input devices individually. Perform calibration procedures according to manufacturer's recommendations.
 - .4 Verify all binary output devices (relays, solenoid valves, two-position actuators and control valves, magnetic starter, etc.) operate properly and normal positions are correct.

-
- .5 Verify all analog output devices (I/Ps, actuators, etc) are functional, that start and span are correct, and that direction and normal positions are correct. The contractor shall check all control valves and automatic dampers to ensure proper action and closure. The contractor shall make any necessary adjustments to valve stem and damper blade travel.
 - .6 Verify the system operation adheres to the sequences of operation. Simulate and observe all modes of operation by overriding and varying inputs and schedules. Tune all DDC loops and optimal start/stop routines.
 - .7 Alarms and Interlocks
 - .1 Check each alarm separately by including an appropriate signal at a value that will trip the alarm.
 - .2 Interlocks shall be tripped using field contacts to check the logic, as well as to ensure that the fail-safe condition for all actuators is in the proper direction,
 - .3 Interlock actions shall be tested by simulating alarm conditions to check the initiating value of the variable and interlock action.
 - .2 System Closeout Reports.
 - .1 The following standard reports shall be provided upon substantial completion:
 - .1 All Points in Alarm Report: Provide an on demand report showing all current alarms.
 - .2 All Points in Override Report: Provide an on demand report showing all overrides in effect.
 - .3 Commissioning Report: Provide a one-time report that lists all equipment with the unit configuration and present operation.
 - .4 Points report: Provide a report that lists the current value of all points

3.22 Cleaning

- .1 Provide The BAS manufacturer's installing contractor(s) shall clean up all debris resulting from their installation activities on a daily basis. The installation contractors shall remove all cartons, containers, crates, etc. under his control as soon as their contents have been removed. Waste shall be collected and placed in a location designated by the Owner, Construction Manager, General Contractor, and/or Mechanical Contractor.
- .2 At the completion of work in any area, the installation contractor shall clean all of their work, equipment, etc., making it free from dust, dirt and debris.
- .3 At the completion of work, all equipment furnished under this Section shall be checked for paint damage. Any factory finished paint that has been damaged shall be repaired to match the adjacent areas. Any metal cabinet or enclosure that has been deformed shall be replaced with new material and repainted to match the adjacent areas.

3.23 Training

- .1 Provide minimum of (4) training sessions, and (4) hours for each session, throughout the contract period. The training will be provided for personnel designated by the Owner.
- .2 These objectives will be divided into logical groupings; participants may attend one or more of these, depending on level of knowledge required:
 - .1 Day-to-day BAS Operators
 - .2 BAS Troubleshooting & Maintenance
- .3 The instructor(s) shall be factory-trained and experienced in teaching this technical material.
 - .1 Training will begin when the operating and maintenance manuals have been delivered to the Owner or reviewed by the Engineer's Representative.
 - .2 Building Walk through and location of Control devices
 - .3 Operating procedures
 - .4 Maintenance procedures
 - .5 Trouble-shooting procedures
 - .6 Spare parts required
- .4 Project Record Documents: Upon completion of installation, submit three (3) copies of record (as-built) documents in addition to an electronic copy. The documents shall be submitted for approval prior to final completion and include:
 - .1 Project Record Drawings - These shall be as-built versions of the submittal shop drawings. One set of electronic media .pdf drawing files shall be provided.
 - .2 Testing and Commissioning Reports and Checklists signed off by trained factory (equipment manufacturers) and field (BAS) commissioning personnel.
 - .3 Operating and Maintenance (O & M) Manuals - These shall be as-built versions of the submittal product data. In addition to the information required for the submittals, Operating & Maintenance manual shall include:
 - .1 24-hour/7-day per week emergency service telephone numbers of Contractor service department along with names, address of service personnel responsible for supporting the ongoing warranty and services of the control system.
 - .2 Preventative Maintenance and calibration procedures; hardware troubleshooting; and hardware repair and/or replacement procedures.
 - .3 One set of electronic media containing files of all operator color graphic screens for the project.
 - .4 Local Supply store should have a minimum 3 unit controllers, System controllers, and room sensors available for same day purchase.
 - .5 Documentation, installation, and maintenance information for all third party hardware/software products provided including personal computers, printers, hubs, sensors, valves, etc.

-
- .6 Original issue media for all software provided, including operating systems, programming language, operator workstation software, and graphics software.
 - .7 Licenses, Guarantee, and Warranty documents for all equipment and systems.
 - .8 Recommended preventive maintenance procedures for all system components including a schedule of tasks (inspection, cleaning, calibration, etc.) and task descriptions.

3.24 System sequences of operation

- .1 All units and systems shall be controlled as described on the Drawings and as recommended by equipment manufacturers.
- .2 Refer to the drawings for sequence of operation.

3.25 Installation of Control for Variable Air Volume Boxes

- .1 Controls vendor shall be responsible for the supply of all controls components required for the control of Variable Air Volume boxes.
- .2 Supply controls components to variable air volume box manufacturer for factory installation of controls components as part of box assembly.

END OF SECTION

PART 1 - GENERAL

1.1 Related sections

- .1 The General Conditions of the Contract, Supplementary Conditions, and General Requirements are part of this specification and shall be used in conjunction with this section as part of the contract documents. Consult the above for further instructions pertaining to this work. The Contractor is bound by the provisions of Division 0 and Division 1.
- .2 Refer to the University of Toronto Building Automation Systems – Design Standards and Guidelines (“Design Standard”), Revision 7, dated June 21st, 2020, for additional requirements. The Design Standard can be found at this link (https://www.fs.utoronto.ca/wp-content/uploads/2021/06/UofT_FS_BuildingAutomationSystems_DesignStandard.pdf) . Where there are contradictions between the Design Standard and this Section, the Design Standard requirements shall take precedence.
- .3 Section 25 05 01 – Integrated Automation.

1.2 Quality assurance

- .1 The product line being proposed for the project must have an installed history of demonstrated satisfactory operation for a length of 3 years since date of final completion in at least 8 installations of comparative size and complexity.
- .2 No beta level or pilot products with less than 3 years field operation are to be used or tested on Campus without approvals.
- .3 Documentation of this requirement with references shall be available upon request.
- .4 **Approved manufacturers:**
 - .1 Honeywell.

1.3 Submittal requirements

- .1 Submittal information shall be provided to the Engineer or Owner electronically prior to commencing the project.
- .2 Provide the Engineer and Owner, any additional information or data which is deemed necessary to determine compliance with the specifications or which is deemed valuable in documenting and understanding the system to be installed.

1.4 Warranty Requirements

- .1 Warrant all provided sensors, accessories, transmitters, and components for a period of 12 months from the date of commissioning.

PART 2 - PRODUCTS

2.1 Flammable Vapor Sensor

.1 Honeywell Part Numbers:

- .1 MPD Interface Adaptor "1226A-0382"
- .2 Honeywell Analytics Remote Sensor Mounting Kit "S3KRMK"
- .3 Junction Box "2441-0022" to be mounted at eye-level.
- .4 Strobe/Horn "P2WL-P"
- .5 Transmitter "XNX-UTIV-RNCB1"
 - .1 The transmitter must accept input from catalytic-bead sensing technology able to be set to 10% LEL.
 - .2 The transmitter shall be capable of providing at least two levels of password controlled access security to the menu structure for calibration, maintenance and configuration of the device.
 - .3 The transmitter shall contain internal software diagnostics capable of reporting a fault within 3 seconds of detection.
 - .4 The transmitter shall store at least 1,280 alarm and fault events in a circular buffer. Events shall be capable to be sorted by order of occurrence, hour, all events by day, only the alarm events, and only the fault events.
 - .5 The transmitter shall be capable of simulating the alarm events for validation of proper system connection without the use of gas.
 - .6 The transmitter shall have three single pole double-throw relays. Two alarm and one fault.
 - .7 The transmitter shall be capable of inhibiting the output during maintenance to avoid false alarms.
 - .8 The transmitter shall allow for a user configured calibration intervals reminder which provides an advance notification to the user that calibration is due.
 - .9 The transmitter shall provide user configurable warning and fault milliamp indications in the range of 1mA to 4mA and 20mA to 22mA. The transmitter must provide milliamp differentiation indication between a fault and warning signal.

.2 Alarm Setpoints

	FIRST ALARM SET POINT	SECOND ALARM SET POINT
Combustibles	25% LEL	40% LEL

PART 3 - EXECUTION

3.1 Installation and Verification Commissioning

-
- .1 For duct mounting please use JB and duct-mount kit with MPD adaptor.
 - .2 System components to be integrated to HRV Unit controller. Strobe/Horn to be installed within lab confines.
 - .3 Use fittings and pack conduit to ensure classified areas integrity.
 - .4 Operation of functions described under sequence of operation to be verified by a factory certified technician. A commissioning certificate to be issued upon successful completion. The certificate is to mention all the following chemicals covered under sensor operation:
 - .1 Die Hardener
 - .2 Die Lubricant
 - .3 Die Spacer #2
 - .4 Thinner for Spacer #2
 - .5 3M Polyether Adhesive
 - .6 Caulk Try Adhesive
 - .7 Tru-Fit Thinner Silver
 - .8 Tru-Fit Thinner Gold
 - .9 Ethyl Alcohol (95% ABV)
 - .10 Duralay Liquid
 - .5 During commissioning, sensors must be calibrated to star 3.
 - .6 Specifications not mentioned under this section to be in compliance with Section 25 05 00 – Integrated Automation.

3.2 Flammable Vapor Removal Sequence of Operations

- .1 The following is to override any previously indicated Sequence of Operations “In the event of Flammable Vapor Removal”, as mentioned on Drawing sheet M3-02:
 - .1 Activate additional supply and exhaust fan output to run at high speed continuously in the event of flammable vapor concentrations reaching 25% above the Lower Explosive Limit (LEL).
 - .1 Return to regular operating criteria when flammable vapor concentrations fall below 10% from the Lower Explosive Limit (LEL).
 - .2 Activate all fans at high speed in the event flammable vapor concentrations reaching 40% above the Lower Explosive Limit (LEL).
 - .1 Activate Strobe/Horn in the event flammable vapor concentrations reaching 40% above the Lower Explosive Limit (LEL).
 - .2 Return to regular operating criteria when flammable vapor concentrations fall below 10% from the Lower Explosive Limit (LEL).
 - .3 Disarm Strobe/Horn in the event flammable vapor concentrations fall below 10% from the Lower Explosive Limit (LEL).

END OF SECTION

1 GENERAL

1.01 REFERENCES

- .1 Division 00 and Division 01 apply to and are a part of this Section.
- .2 See Section 27 10 00 Structured Cabling for rack mount UPS unit that shall be provided by the Electrical Contractor.

1.02 APPLICATION

- .1 This Section specifies requirements that are common to Electrical 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.
- .2 Be responsible for advising product vendors of requirements of this Section.

1.03 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 cables, 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 including back boxes and exposed piping and raceways; and 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 Consultant.
- .8 "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.
- .9 "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.

- .10 "Mechanical Divisions" - 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.
- .11 "Electrical Divisions" – 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.
- .12 "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.
- .13 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.
- .14 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.

1.04 DOCUMENTS

- .1 Documents for bidding include but are not limited to issued Drawings, Specifications and Addenda.
- .2 Specification is arranged in accordance with CSI/CSC 50 Division Sections 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 Specification 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 Electrical 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 materials. 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.
- .7 Drawings are intended to convey scope of work and do not show architectural and structural details. Provide fittings, offsets, transformations and similar items 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 of Mechanical Divisions specifications and drawings, prior to Bid submission. Confirm and coordinate exact scope of work and responsibility of work between Mechanical Divisions and Electrical Divisions.
- .11 Drawings and Specifications are 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.
- .12 In case of discrepancies or conflicts between Drawings and Specifications, Documents will govern in order specified in "General Conditions", however, when scale and date of Drawings are same, or when discrepancy exists within Documents, include most costly arrangement.

1.05 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. Exact measurements to be confirmed 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.

1.06 EXAMINATION OF BID DOCUMENTS AND SITE

- .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.

1.07 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 Consultant.

- .3 Supplementary mandatory Specifications and requirements to be used in conjunction with project include but are not limited to following:
 - .1 American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc., (ASHRAE);
 - .2 American Standards Association (ASA or ANSI);
 - .3 ANSI/ASHRAE Standard 90.1, Energy Standard for Buildings Except Low-Rise Residential Buildings;
 - .4 Building Industry Consulting Services, International (BICSI);
 - .5 Canadian Standards Association (CSA);
 - .6 CSA C282, "Emergency Electrical Power Supply For Buildings";
 - .7 CSA Z462, "Workplace Electrical Safety";
 - .8 Electrical and Electronic Manufacturers Association of Canada (EEMAC);
 - .9 Electrical Safety Authority (ESA);
 - .10 Illuminating Engineering Society (IES);
 - .11 National Electrical Manufacturers Association (NEMA);
 - .12 National Fire Protection Association (NFPA);
 - .13 Occupational Health and Safety Act (OHSA);
 - .14 Ontario Building Code (OBC);
 - .15 Ontario Electrical Safety Code (OESC);
 - .16 Technical Standards and Safety Authority (TSSA);
 - .17 Underwriters' Laboratories of Canada (ULC);
 - .18 Material Safety Data Sheets by product manufacturers;
 - .19 local utility inspection permits;
 - .20 codes, standards, and regulations of local governing authorities having jurisdiction;
 - .21 additional codes and standards listed in Trade Sections;
 - .22 U of T Electrical Design Standard (Revision 02, 2024-04-23)
 - .23 U of T Fire Alarm Design Standard (Revision 02, 2025-01-09).
- .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.
- .7 Work is to be performed by journeyperson tradesmen who perform only work that their certificates permit, or by apprentice tradesmen under direct on site supervision of experienced journeyperson tradesman. Journeyperson to apprentice ratio is not to exceed ratio determined by the Board as stated in Ontario College of Trades and Apprenticeship Act or local equivalent governing body in Place of the Work.
- .8 Journeyperson tradesmen are to have a copy of valid trade certificates available at site for review by Consultant at any time.
- .9 Experienced and qualified superintendent is to be on-site at times when work is being performed.
- .10 Coordinate work inspection reviews and approvals with governing inspection department to ensure that construction schedule is not delayed. Be responsible for prompt notification of deficiencies to Consultant and submission of reports and certificates to Consultant.
- .11 Properly protect equipment and materials on site from damage due to elements and work of trades, to satisfaction of Consultant. Equipment and materials are to be in new condition upon Substantial Performance of the Work.

1.08 PERMITS, CERTIFICATES, APPROVALS AND FEES

- .1 Contact and confirm with local authorities having jurisdiction including utility providers, requirements for approvals from such authorities.
- .2 Submit required applications, shop drawings, electrical distribution system protection device coordination studies, and short circuit calculations, and any other information requested by local authority.
- .3 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.
- .4 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.
- .5 Include in each copy of operating and maintenance instruction manuals, copies of approvals and inspection certificates issued by regulatory authorities.
- .6 Where electromagnetic locks are provided whether by this Division or by others, be responsible for obtaining and paying for required certificates of work with regards to such electromagnetic lock work.

1.09 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 members in good standing with local Association of Professional Engineers, 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 Liability insurance requirements are as follows:
 - .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.

1.10 WORKPLACE SAFETY

- .1 Comply with requirements of Workplace Hazardous Materials Information System (WHMIS) regarding use, handling, storage, and disposal of hazardous materials. Submit WHMIS MSDS (Material 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 Consultant.

1.11 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 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. Remove and replace any 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.

1.12 COMPONENT FINAL LOCATIONS

- .1 Owner and Consultant reserve right to relocate electrical components such as receptacles, switches, communication system, outlets, hard wired outlet boxes and luminaries at a later date, but prior to installation, without additional cost to Owner, if relocation per components do not exceed 3 m (10') from original location. No credits will be anticipated where relocation per components of up to and including 3 m (10') reduces materials, products and labour. Should relocations exceed 3 m (10') from original location, adjust contract price for that portion beyond 3 m (10') in accordance with provisions for changes in Contract Documents.

1.13 SYSTEMS COORDINATION

- .1 Be responsible for and perform specific coordination of various low voltage systems supplied by Electrical Divisions and also with systems supplied by other Divisions of Work. Include for but not be limited to provision of following, as applicable:
 - .1 coordinate with General Contractor and other Subcontractors, various systems of trades which in any way are interfaced with or monitored by or integrated to, or need to be coordinated with;
 - .2 prepare systems coordination drawings detailing related system coordination and integration points being monitored and/or controlled; submit coordination drawings as part of shop drawing submission;

- .3 coordinate security system requirements with successful door hardware supplier and prepare detailed coordination drawings of component installations, wiring and conduit layouts, division of responsibility between various trades, etc.; review security system requirements with associated door hardware (electromagnetic locks, electric strikes, etc.), to ensure proper sequence of operation and door functionality is provided to suit each door configuration; prepare detailed door functionality of each door configuration and submit for review by Consultant;
- .4 review systems requirements for component back boxes and conduits; ensure that system of conduits and boxes meet respective system wiring bending radii requirements;
- .5 review specifications of each trade/Division (i.e. for BAS points, elevator requirements, electrical devices in millwork or prefabricated service consoles, outlet box and back box requirements), to ensure proper power supplies, interconnecting wiring requirements and back box/ outlet box requirements;
- .6 review with manufacturers coordination and integration requirements of their systems;
- .7 review each systems communication protocols to ensure they are compatible and can communicate with each other as required;
- .8 review system shop drawings prior to submission to Consultant, to verify that each system has been coordinated with other systems and that required options and features are selected to meet coordination requirements;
- .9 be present at testing and commissioning functions of each system and provide technical assistance with regards to system operations;
- .10 be "on-site" coordinator of respective system trades with regards to respective system coordination of installation and testing;
- .11 coordinate with Consultant with regards to ensuring that systems coordinate and integrate properly to satisfaction of Owner;
- .12 document coordination and integration requirements and maintain records for submission as part of shop drawings;
- .13 respond to coordination and integration requirements and be responsible for such work;
- .14 where a system integrator has been included for, coordinate integration requirements with system integrator.

1.14 PRODUCTS

- .1 Be responsible for ordering of products (equipment and materials) in a timely manner in order to meet project-scheduling timelines. Failure to order products to allow manufacturers sufficient production/delivery time to meet project-scheduling timelines is an unacceptable reason to request for 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 and are to comply with applicable respective Canadian standards. References to UL listings of products to include requirements that products are to be also Underwriters Laboratories of Canada (ULC) listed for use in Canada. Products are to meet or exceed latest ANSI/ASHRAE/IES 90.1 standards, as applicable. Do not supply any products containing asbestos materials or PCB materials.
- .3 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.
- .4 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.
- .5 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 in Division 01 with regards to substitutions or failure to supply product
- .6 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.
- .7 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.

- .8 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 accepted in writing by Consultant.
- .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 Products supplied by a manufacturer/supplier other than a manufacturer listed as acceptable may be considered for acceptance by Consultant if requested in writing with full product documentation submitted, a minimum of 10 working days prior to Bid closing date.
- .12 Any proposed changes 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 Consultant, and costs for review, to be borne by Contractor.
- .13 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.
- .14 Requirements for low voltage systems of this project that are of technology that changes rapidly and are forever evolving and changing, resulting in systems that may be out dated by time of installation, are to include provisions to allow Owner option to select most updated technology. Shop drawings for such systems and equipment are to include provisions for a minimum 6-week review time for Owner to review degree of technology of each system and determine acceptance. Owner will have right to substitute a more advanced technology subject to negotiated pricing.

1.15 SHOP DRAWINGS

- .1 At start-up meeting confirm 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. Confirm exact requirements with Consultant.
- .3 Submit for review, drawings showing in detail design, construction, and performance of equipment and materials as requested in Specification. 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.
- .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 "RETURNED FOR CORRECTION" – 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 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 CO-ORDINATION 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.
- .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 completed by 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.

1.16 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. Be responsible for confirming locations of equipment with Consultant prior to construction.

1.17 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.
- .2 No openings are permitted through completed structure without written approval of 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 directed by Owner and coordinated with Consultant, do not leave any openings unprotected and unfinished overnight.

1.18 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 of Consultant.
- .2 Immediately remove from site scaffolding, rigging and hoisting equipment when no longer required.
- .3 Do not place major scaffolding/hoisting equipment loads on any portion of structure without approval from Consultant.

1.19 CHANGES IN THE WORK

- .1 Whenever Consultant proposes in writing to make a change or revision to design, arrangement, quantity, or type of any work from that required by Contract Documents, prepare and submit to Consultant for approval, a quotation being proposed cost for executing change or revision.
- .2 Quotation 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 confirmed with Consultant prior to contract signing, then allowable maximum percentages for overhead and profit are to be 7% and 5% respectively.
- .4 Unless otherwise specified in Divisions 00 or 01, following additional requirements apply to quotations submitted:
 - .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;
 - .3 electrical material labour unit costs are to be in accordance with National Electrical Contractors Association Manual of Labor Units at difficult level, less 25%;
 - .4 costs for journeyman and apprentice labour must not exceed prevailing rates at time of execution of Contract and must reflect actual personnel performing work;
 - .5 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;
 - .6 costs for rental tools and/or equipment are not to exceed local rental costs;
 - .7 overhead percentage will be deemed to cover quotation costs other than actual site labour and materials, and rentals;
 - .8 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.
- .6 Make requests for changes or revisions to work to Consultant in writing and, if Consultant agrees, will issue Notice of Change.
- .7 Do not execute any change or revision until written authorization for change or revision has been obtained from Consultant.

1.20 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 Consultant's approval and 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 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 they will be indicated on progress draw.

1.21 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 5 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.

1.22 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.

1.23 TEMPORARY SERVICES

- .1 Coordinate with General Contractor, requirements for temporary services including but not limited to temporary electrical power, lighting and exit pathways. Locations of exit pathways to be as decided at discretion of General Contractor, and to be illuminated complete with emergency lighting, and provided with exit signage and fire alarm devices in accordance with requirements of local governing building code and local governing inspection authorities.
- .2 Temporary power requested by contractor during construction shall be metered and charged back to contractor. Contractor shall provide meter (make and model), as specified by U of T F&S.

1.24 CLEANING

- .1 During construction, keep site reasonably clear of rubbish and waste material resulting from work on a daily basis to the satisfaction of 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 At time of final cleaning, clean luminaire reflectors, lenses, and other luminary surfaces that have been exposed to construction dust and dirt, including top surface, whether it is exposed or in ceiling space.
- .3 Clean switches, receptacles, communications outlets, coverplates, and exposed surfaces.
- .4 Clean other electrical equipment and devices installed as part of this project.
- .5 For work performed in electrical equipment rooms, electrical closets and communication closets, perform following:
 - .1 HEPA vacuum and clean interiors and buswork of switchboards, panels, cabinets and other electrical equipment of construction debris and dust prior to energization;
 - .2 HEPA vacuum top of switchboards, panels, cabinets, bus ducts, cable trays and conduits in room, followed by a thorough HEPA vacuuming of floors;
 - .3 do not lay permanent switchboard matting in electrical rooms until rooms are re-cleaned, and floors wet mopped and dried just prior to final turn over to Owner.

1.25 RECORD AS-BUILT DRAWINGS

- .1 Drawings for this project have been prepared on a CAD system using AutoCAD software of release version confirmed with Consultant. For purpose of producing record "as built" drawings, copies of Contract Drawings can be obtained from Consultant.

- .2 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, and ensure set is available for periodic review. As-built set is also to include following:
 - .1 dimensioned location of inaccessible concealed work;
 - .2 locations of control devices with identification for each;
 - .3 location and identification of devices in concealed locations such as accessible ceiling spaces and raised floors;
 - .4 location of concealed services terminated for future extension and work concealed within building in inaccessible locations.
 - .5 location of fire alarm devices and include addresses of devices; identify fire alarm zones;
 - .6 identify routing and location of concealed conduits/ducts of diameter 50 mm (2") and greater;
- .3 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.
- .4 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.
- .5 Submitted drawings are to be of same quality as original Contract Drawings. CAD drawing files are to be compatible with AutoCAD software release version confirmed with Consultant.
- .6 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 Consultant.
- .7 Modify existing posted single line electrical distribution drawings with revised information to reflect renovations and revisions to electrical distribution equipment. Drawings to be of type to match existing as confirmed with Owner. Supply electronic files of format confirmed with Owner for following:
 - .1 fire alarm system test report devices and addresses;

1.26 OPERATING AND MAINTENANCE MANUALS

- .1 Submit draft copy to Consultant for review. Incorporate any Consultant's comments in preparation final manuals.

- .2 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) instruction data manuals. Confirm 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 label; wording – "Electrical 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 Maintenance data is to include:
 - .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;
 - .4 complete parts lists with numbers.
 - .7 Performance data is to include:
 - .1 equipment and system start-up data sheets;
 - .2 equipment test reports;
 - .3 final verification and commissioning reports.
 - .8 explanation of operating principles and sequences;
 - .9 inspection certificates issued by regulatory authorities;
 - .10 wiring and connection diagrams;
 - .11 copies of new, additional and revised panelboard directories, using UofT standard panel schedule templates. Download templates from link "[The University of Toronto's design standards and project forms](#)";
 - .12 warranties;

- .13 items requested specifically in Section Articles.
- .3 Generally, binders are not to exceed 75 mm (3") thick and not to be more than 2/3 full.
- .4 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.
- .5 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.
- .6 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 confirmed with Consultant and enhanced with bookmarks and internal document links.

1.27 COMMISSIONING

- .1 Commissioning Agent is appointed by Owner to oversee commissioning activities of contract, except for commission of security, fire alarm, audio visual and communications systems.
- .2 Interface, cooperate and coordinate with Commissioning Agent and attend commissioning meetings. Perform commissioning activities for aspects of work provided in Electrical Divisions and perform corrective work identified by Commissioning Agent.
- .3 Submit copies of submittals such as O&M manuals, shop drawings, schedules and test reports of systems and equipment to Commissioning Agent, prior to start of commissioning activity or as directed by Commissioning Agent.
- .4 Commissioning Agent may also be present for any testing/commissioning activities. Notify Commissioning Agent in advance of these activities.
- .5 Refer to Division 01 Section 01 91 15 for additional commissioning requirements. Refer to Section 26 08 15 entitled Electrical Commissioning for additional requirements. Section 01 91 15 and Section 26 08 15 are provided by the Commissioning Agent.
- .6 Where commissioning specifications are included as part of Division 01, requirements of Section entitled Electrical Work Commissioning are to supplement commissioning requirements of Division 01. Where variances or contradictions exist, more stringent requirement will apply unless otherwise directed by Consultant.

1.28 PROJECT CLOSE OUT SUBMITTALS

- .1 Prior to application for Substantial Performance of the Work, submit required items and documentation specified, including following:
 - .1 Operating and Maintenance Manuals;
 - .2 as-built record drawings and associated data;
 - .3 final power system studies (see Section 26 05 70 for details);

- .4 extended warranties for equipment as specified;
- .5 operating test certificates;
- .6 final commissioning report;
- .7 identified keys for equipment and/or panels for which keys are required, and other items required to be submitted;
- .8 other data or products specified.

1.29 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 Operating and Maintenance 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.
- .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.

1.30 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 maintenance and operating data have been completed and submitted to, reviewed and accepted by Consultant;
 - .4 tags and nameplates are in place and equipment identifications have been completed;
 - .5 clean-up is complete;
 - .6 spare parts and replacement parts specified have been provided and acknowledged by Consultant;
 - .7 as-built and record drawings have been completed and submitted to, reviewed and accepted by Consultant;
 - .8 Owner's staff has been instructed in operation and maintenance of systems;
 - .9 commissioning procedures have been completed.

2 PRODUCTS

NOT USED

3 EXECUTION

NOT USED

END OF SECTION

1 GENERAL

1.01 APPLICATION

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

1.02 SUBMITTALS

- .1 Submit shop drawings for products of this Section.
- .2 Additionally as part of shop drawing submission process, submit following to Consultant for review:
 - .1 sample of each proposed type of access door if supplied under work of this Division, as well as electronic copies of reflected ceiling plan drawings and wall elevation drawings showing proposed access door locations;
 - .2 samples of materials and any other items as specified in succeeding Sections of Electrical Divisions;
 - .3 weight loads of selected equipment (upon request);
 - .4 equipment nameplate and warning sign proposed nomenclature, print type, symbols, sizing and colours;
 - .5 fire stopping installation drawings with ULC certifications;
 - .6 copies of prior to start of construction approvals from local governing authorities having jurisdiction.
- .3 Prior to application for Substantial Performance of the Work, submit following to Consultant for review (note: funds will be withheld until each of following items have been completed and documented to satisfaction of Consultant):
 - .1 fire alarm system testing and verification report of each component of work; devices to be certified working and in proper order;
 - .2 final distribution system testing and arc flash study performed and documented to satisfaction of Consultant;

1.03 CONTINUITY OF SUPPLY FOR STANDARDIZATION

- .1 Utilize materials of one manufacturer for aspects of work, where practical. Utilize one common manufacturer for wiring devices, such as switches and receptacles, whether installed loose or in a pre-manufactured component. Coordinate with each supplier and ensure conformance with this requirement. Identify deviations to Consultant and obtain approval of change prior to proceeding with work.

1.04 HAZARDOUS MATERIALS

- .1 Hazardous materials and infectious materials are known to be present on site in existing buildings, including but not limited to following:

- .1 aspergillus;
 - .2 mould;
 - .3 asbestos;
 - .4 PCBS;
 - .5 lead;
 - .6 mercury.
- .2 Division 01 identifies specific requirements and if such materials are present, include for costs to be educated and trained on special working conditions, to work in areas with hazardous materials including protective clothing, gear, tenting, enclosures, etc., and perform necessary partitioning/tenting/ventilation work to isolate areas and maintain disturbances of such materials to a minimum. Comply with infection control requirements and those of governing local Health and Welfare authority. An asbestos abatement report is available for review from Consultant. Unless otherwise noted, any abatement removal is responsibility of another Division of Work.
- .3 For information of asbestos and other designated substances and abatement scope of work, please refer to the documents issued with the overall tender package.
- .4 If proper abatement procedures are not followed, be responsible for bearing full cost of a full time qualified abatement inspector chosen by Owner. In areas where work is being done above or below an area being occupied, any slab penetrations into vertically adjacent occupied space are to utilize a proper enclosure in area of that work on that occupied floor. Be responsible for failure to comply with special requirements in working in areas of hazardous materials.
- .5 Include for company specializing in removal and disposal of materials containing PCB's to remove and dispose off-site luminaire ballasts containing PCB's. Check luminaires being deleted for ballasts containing PCB's. Disconnect and dispose off-site such ballasts. Only companies that are certified and comply with Ministry of Environment and Ministry of Transport regulations with regards to hazardous waste materials are to be used to perform this Work. Prior to start of Work, submit to Consultant a copy of PCB disposal certificate and identification of Ministry authorized and designated disposal site.
- .6 Fluorescent lamps being replaced and containing mercury are to be properly transported offsite and disposed of as per local governing Ministry guidelines.

1.05 REQUESTS FOR ELECTRICAL SHUTDOWN

- .1 All requests for Electrical Shutdown shall be submitted online through the 'Request for Electrical Services' (RES) portal (<https://res.fs.utoronto.ca>), which requires UTORid authentication. Contractors shall work with the project manager (PM) to complete Electrical Shutdown Requests submissions.
- .2 Panel schedule shall be submitted at the Shutdown Request stage.
- .3 Short circuit/Arc flash calculations will also be requested at the shutdown stage to ensure the connected loads meet the OESC requirements for labelling of electrical equipment. This will be specifically requested at the Shutdown stage for replacement / relocation of existing panelboard, addition / remove of temporary power distribution equipment, addition of new panelboard(s), new transformer(s), and/or new transfer switch(es).
- .4 The supporting documents for Electrical Shutdown Requests is recommended to be submitted for U of T Facilities & Services (F&S) review prior to the shutdown request to ensure timely scheduling of shutdowns.

2 PRODUCTS

2.01 CONDUITS

- .1 EMT (Thinwall), galvanized electrical metallic tubing to CSA C22.2 No. 83, complete with factory made bends where site bending is not possible and joints and terminations made with steel couplers and steel set screw type connectors with insulated throats, and concrete tight where required.
- .2 Galvanized steel flexible liquid tight metallic conduit to CSA C22.2 No. 56, complete with Ideal "Steel Tough" liquid-tight flexible conduit connectors at terminations.
- .3 Galvanized steel flexible metallic conduit to CSA C22.2 No. 56, complete with proper and suitable squeeze type connectors at terminations.

2.02 OUTLET BOXES

- .1 CSA approved stamped galvanized steel outlet boxes.
- .2 Each outlet box and back box to be suitable in respects for application and complete with suitable securing lugs, connectors suitable for connected conduit, knockouts and, where necessary, suitable plaster rings, concrete rings, covers, carpet flanges and any other required accessory.
- .3 Electrical boxes exposed exterior of building or in non-climate controlled locations to be weatherproof boxes complete with gasketted covers/faceplates.

2.03 PULLBOXES AND JUNCTION BOXES

- .1 Galvanized or prime coat plated steel, suitable in respects for application and complete with screw-on or hinged covers as required, and connectors suitable for connected conduit.
- .2 Physical size of pullboxes to be as required by local governing electrical code to suit number and size of conduits and conductors.
- .3 Each box to be suitable in respects for application and complete with suitable securing lugs, connectors suitable for connected conduit, knockouts and, where necessary, suitable plaster rings, concrete rings, covers and any other required accessory.
- .4 Boxes exposed exterior of building or in non-climate controlled locations to be weatherproof boxes complete with gasketted covers.

2.04 DISCONNECT SWITCHES

- .1 Heavy duty, CSA approved, disconnect (safety) switches. Features include:
 - .1 front operated with a handle suitable for padlocking in "OFF" position and arranged so that enclosure cover cannot be opened while handle is in "ON" position
 - .2 operating mechanisms: quick-break, positive acting with visible blades and a line terminal shield;
 - .3 ampere rating and number of poles as indicated on drawings;

- .4 factory primed and painted switch enclosures.
- .2 Disconnects for variable speed drives to be suitable for use with such drives and include auxiliary switch/contact to de-energize control power circuit, as required and as applicable.
- .3 Enclosures for disconnects mounted in interior climate-controlled areas and standard non-climate controlled areas to be NEMA 3R. For corrosive environmental applications, enclosures to be minimum NEMA 4X.
- .4 Acceptable manufacturers are:
 - .1 Eaton (Cutler-Hammer);
 - .2 Siemens Electric Ltd.;
 - .3 Schneider Electric (Square D).

2.05 NEW BREAKER IN EXISTING 600V PRIMARY SWITCHGEAR

- .1 Withdrawable type breakers shall:
 - a. have a minimum of three 52a and three 52b contacts, brought out to accessible terminals inside the equipment. One of the 52a signals, per breaker, shall be wired to the switchgear's main meter.
 - b. be equipped with a minimum of 3 racking positions: 'connected', 'test', 'disconnected'. Visual or mechanical indication shall be provided showing the 3 positions in the racking path.
 - c. be equipped with a provision for remote operation. This signal shall be brought out to accessible terminals inside the equipment. Breakers shall also be capable of being manually charged, opened, and closed.
 - d. have mechanical interlocks to ensure that a breaker is open before it can be racked in to or out of the 'connected' position.
 - e. come with an electronic LSI(G) trip unit, fully programmable to allow time delays for each trip type to aide with short circuit coordination. The trip unit shall digitally display rudimentary real time metering values (I, V, kW).
 - f. be lockable in the disconnected position. The cell door shall be capable of remaining closed while the breaker is racked in to and out of the 'disconnected' position.
 - g. be equipped with a breaker operations counter.
- .2 The rated ultimate breaking capacity (Icu) of the air circuit breaker shall be equal to at least the value of the short-circuit current (Isc) at the point of installation on the electric circuit.
- .3 Breaker trip units shall be self-powered and shall not require an external power source for proper operation. Battery use for protection functions is not acceptable.
- .4 Trip units shall have visual indication of the reason for tripping. Trip indicators shall be latching type and remain in position until manually reset.

- .5 All load breakers shall be fitted with a communication module capable of transmitting metering data to the switchgear's main meter.
- .6 Air circuit breaker's manufacturer shall provide selectivity and coordination tables with other devices such as other air circuit breakers, switches etc.
- .7 Mechanical durability shall be at least 12500 operations.
- .8 Where remote operation and monitoring is required,
 - .1 circuit breakers shall have separate status LEDs indicating CLOSED, OPEN, and TRIPPED conditions. A 'LAMP TEST' push button shall be provided to test the integrity of all associated LEDs for that breaker. A complete set of spare LEDs shall be provided. Colour coding shall be as follows:
 - .1 RED: Breaker CLOSED
 - .2 GREEN: Breaker OPEN
 - .3 WHITE: Breaker TRIPPED
 - .2 Circuit breaker control switches shall be pistol grip type, three positions (open-home-close) with target indication of the last operation and spring return to the home position. Target indication shall be red for breaker closed & green for breaker open.
 - .3 Circuit breaker remote open/close signals shall be provided, and signals shall be terminated in the designated control compartment of the breaker.
- .9 Wiring and Connections
 - .1 Where single conductor cables or bus ducts are used, a removable nonferrous cable entry plate shall be provided where the conductors enter or leave the cell, unless bottom entry/exit in indoor locations.
 - .2 Secondary and control wiring shall be identified at each point of connection/termination by permanent, printed, non-metallic wire markers, which shall agree with the wiring diagrams.
 - .3 All wiring within the control compartments shall be free of splices and terminated on appropriately rated termination points. All terminal blocks shall be barriered type, permanently labelled and shall agree with the wiring diagrams. Terminals shall be identified with electronically printed characters and made permanent. Terminal blocks shall have no more than one wire under each terminal connection.
 - .4 Secondary and control wiring originating and terminating inside the switchgear shall be copper SIS type. Wiring shall be minimum #14 AWG. Current transformer secondary wiring shall be minimum #12 AWG.
 - .5 Any fuses used shall be installed in finger safe disconnecting style fuse holders. Three phase applications shall be gang operated.
- .10 Instrument Transformers
 - .1 Metering CTs shall be revenue grade and rated ANSI/IEEE C57.13 0.3B0.5 or greater (0.3% accuracy at 100% rated primary current with a burden not to exceed 0.5 Ohm). Primary current rating shall be specified as the closest rating available, equal to or greater than the trip rating of device being metered.

- .2 Potential transformer(s), where required, shall be configured as three 120V 'Wye' connected secondary windings. Transformer kVA rating shall be sized to provide the designed load when used for metering. Potential transformers shall not be used for providing power to any device. An appropriately sized Control Power Transformer (CPT) shall be used for power applications.
- .3 All voltage and current secondary circuits shall be brought out to an FT switch located on the front of switchgear for secondary injection testing/calibration. A separate FT switch shall be used for each device. Secondary current circuits shall be provided with shorting means through the FT switches. Secondary voltage circuits shall be provided with an isolating means through the FT switch.
- .4 Metering CTs shall all be installed on the immediate load side of any breaker being metered.
- .5 Metering PT's primary or voltage sensing shall all be connected on the immediate load side of any breaker being metered.
- .6 Metering CPT's primary or control power shall be connected on the immediate line side of any breaker being metered.

2.06 ADDITIONAL DEVICES FOR OTHER EXISTING EQUIPMENT

- .1 Additional breakers and switch and fuses assemblies for existing panelboards and/or MCCs are to match existing device standards and be completely compatible to board in which they are installed. During Bidding period, check and verify exact requirements of existing equipment to ensure that additional devices are accommodated.
- .2 Products to be of types from existing equipment manufacturers. Confirm existing equipment requirements with respective manufacturers of equipment.
- .3 For additional breakers and components as noted specifically on drawings, provide necessary accessibilities, components, and connections. Coordinate with other trades' works.
 - .1 All breakers with frame sizes 800A or greater shall be of the withdrawable type.
 - .2 Thermal motor breakers are not acceptable in any panelboards or switchgear.
 - .3 All breakers with frame sizes of 200A or greater shall have an electronic trip unit with LSI settings at a minimum.
 - .4 Breaker trip units shall be self-powered and shall not require an external power source for proper operation. Battery use for protection functions is not acceptable.
 - .5 Trip units shall have visual indication of the reason for tripping. Trip indicators shall be latching type and remain in position until manually reset.
- .4 Make necessary modifications to existing equipment to accommodate device and feeder installation. Provide suitable engraved lamacoid identification nameplate on additional components. Revise typed circuit directory cards on branch circuit panelboards. Mount additional devices to standards of existing equipment manufacturer.

- .5 Provide additional retrofit work to existing equipment as noted on drawings. Delete breakers as noted. Revise mimic bus and nameplates accordingly. Refer to notes on drawings for other requirements.

2.07 SLEEVES

- .1 Galvanized steel sleeves as follows:
 - .1 No. 24 gauge with an integral flange at one (1) end to secure sleeve to formwork construction;
 - .2 Schedule 40 pipe;
- .2 Schedule 40 PVC sleeves.

2.08 FIRESTOPPING AND SMOKE SEAL MATERIALS

- .1 Asbestos-free, elastomeric materials and intumescent materials, tested, listed and labelled by ULC in accordance with CAN 4-S115-M85, and CAN/ULC-S101-M 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 Fire stopping 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 number for each specific installation. Submit schedule of opening locations and sizes, penetrating items, and required listed design numbers to seal openings to maintain fire resistance ratings.
- .3 Systems to consist of both elastomeric and intumescent materials that are compatible with abutting dissimilar materials and finishes. Coordinate material requirements with trades supplying abutting areas of materials.
- .4 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.
- .5 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.
- .6 Supply products of a single manufacturer for use on work of this Division.
- .7 Installer to be manufacturer trained and certified on specific product. Submit copy of certificate with shop drawings.
- .8 Include for manufacturer's authorized representative to inspect and verify each installation and application. Submit test report signed and verified by system installer's authorized representative and manufacturer's representative.
- .9 Acceptable certification to also include certification by Underwriters Laboratories of Northbrook IL, using tests conforming to ULC-S115 and given cUL listing published by UL in their "Products Certified for Canada (cUL) Directory".

- .10 Acceptable manufacturers are:
 - .1 Specified Technologies Inc.;
 - .2 3M Canada Inc.;
 - .3 Tremco;
 - .4 A/D Fire Protection Systems;
 - .5 Nelson;
 - .6 Hilti Canada.

2.09 FASTENING AND SECURING HARDWARE

- .1 Concrete inserts - for concrete work for runs of conduits, cable tray, etc., equipment or where a grid support system is required.
- .2 Concrete fasteners – "WEJ-IT" anchors, lead cinch anchors and/or "STAR" or "PHILLIPS" self-drilling anchors.
- .3 Masonry inserts – "WEJ-IT" expansion shields and machine bolts or, for light loads, fibre or lead plugs and screws.
- .4 Drywall or plaster wall and/or ceiling fasteners – 2-wing spring toggles.
- .5 Structural steel - beam clamps.
- .6 Metal framing channels – 40 mm (1-5/8") width, galvanized steel channels complete with required fittings and ancillary hardware; acceptable manufacturers are:
 - .1 Unistrut;
 - .2 Thomas & Betts;
 - .3 Eaton B-Line.
- .7 Metal "J" hooks or Panduit "J-Pro" cable support systems for communications system cabling in accessible ceiling spaces where conduit or cable tray is not being provided. Obtain written approval of Consultant for use of J-hooks.
- .8 Velcro tie wraps for bundling and securing cables.

2.10 SYSTEM BACKBOARDS

- .1 Construction grade fir plywood, containing no added urea formaldehyde, flame retardant prime coat painted on exposed surfaces, minimum 20 mm (3/4") thick, as sized on drawings and with flame spread rating in accordance with local governing building code requirements.

2.11 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 that access doors on project are provided by a single manufacturer, installed as part of work of General Trades Contractor and that work involving both mechanical and electrical services to where possible be accessible from common access door. Coordinate work to ensure that same common location access doors are not supplied by more than one Division.

- .3 Size access door to suit concealed work for which they are supplied and wherever possible they are to be of standard size for all applications, but in any case they are to be 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 ceilings, walls, partitions, structures, etc., 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.

2.12 IDENTIFICATION NAMEPLATES

- .1 Laminated plastic (Lamacoid) black-white-black with bevelled edges, stainless steel screws, and proper identification engraving. Each nameplate to be sized to suit equipment for which it is provided, and required wording. Confirm nomenclature with Consultant. Various colour configurations to be used to differentiate systems. Confirm exact colour scheme with Consultant and/or Owner. The Lamacoid shall reference the upstream protection device's panelboard, circuit, and room number.
- .2 Lamacoid shall have text with height as: Size A - 25mm; Size B - 13mm; Size C - 6mm.
- .3 When identifying pieces of electrical equipment, except for breakers/switches, the Primary Lamacoid of size A shall indicate the equipment identifier tag as per Numbering System for Electrical Equipment below. The Secondary Lamacoid of size C shall be installed immediately below the Primary and indicate the source of supply identifier tag and room number. For any subsequent requirements, refer to the specific equipment sections within this document.
- .4 Lamacoid text and background colour shall be white text on a black background, except in the following cases:
 - i. White background with:
 - Green text upstream of ATS or primary ATS(s) within the building for emergency source (life/non-life safety).
 - Red text for ATS(s) and equipment (life/non-life safety) downstream of ATS(s) within the building.
 - Blue text for UPS sourced equipment.
 - ii. Red background with white text for:
 - Critical equipment
 - Safety or hazard information
- .5 Refer to the following for equipment lamacoid examples:
 - i. Standard naming convention:

078-NDP-B1-06-DA

FED FROM 078-NTX-B1-41-AD

In Rm. 1008

- ii. Equipment upstream of ATS(s) fed from the emergency source within the building, inclusive of emergency source (life/non-life safety):

- Any isolations of green labelled equipment will not result in load loss.

006-ECB-B2-06-AA

FED FROM 006-EDP-B2-06-AA

In Rm. 0022

- iii. ATS(s) and equipment (life/non-life safety) downstream of ATS(s) within the building:

- Any isolations of red labelled equipment will result in load loss.

005-EAT-05-02-DF

FED FROM 005-EDP-03-06-DA

In Rm. 3337

- iv. Blue text for UPS sourced equipment:

160-URP-12-02-AA

FED FROM 160-UUP-12-02-AA

In Rm. 1275

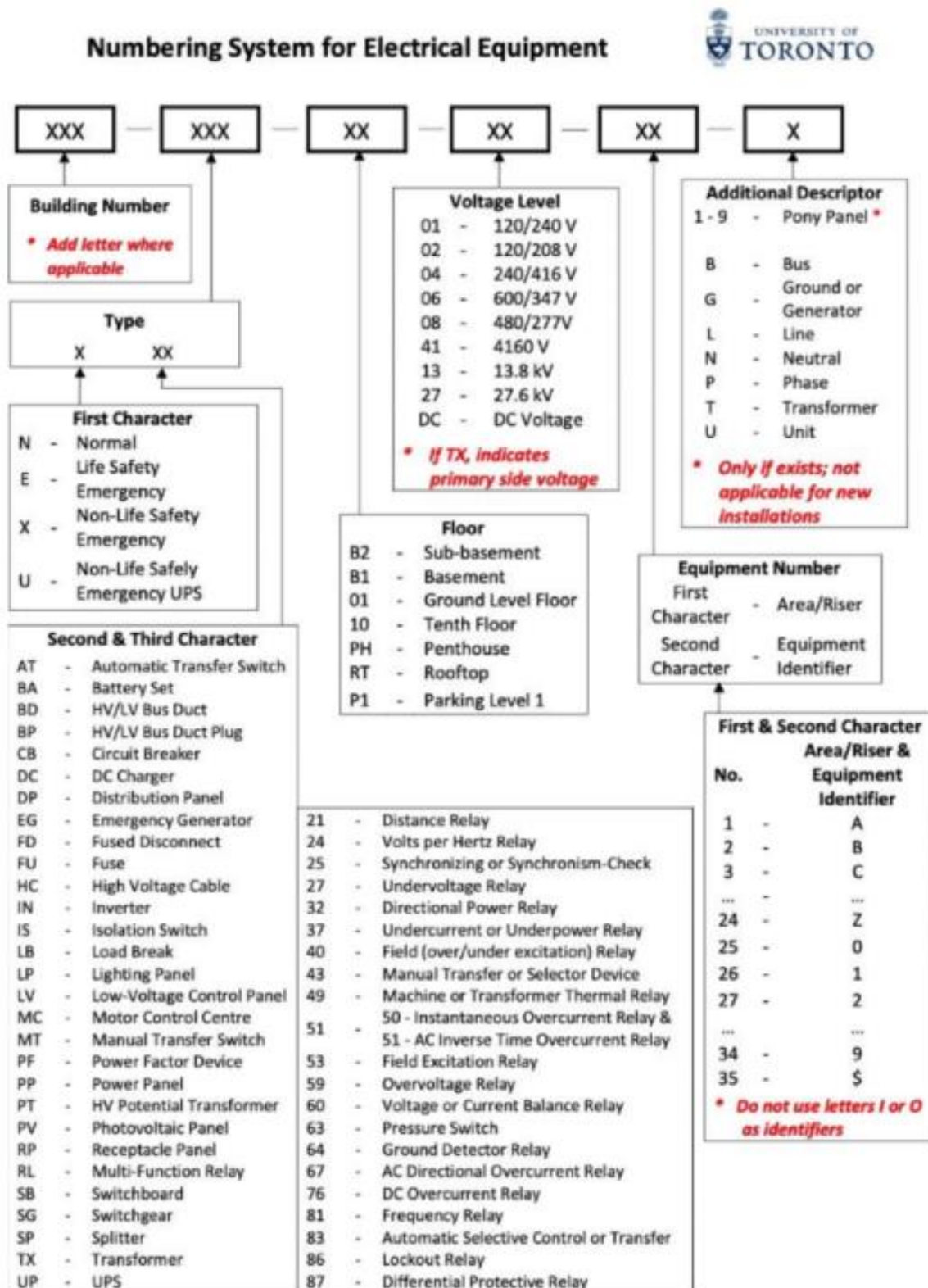
- v. Critical equipment or safety or hazard information:

DANGER

Operate Under Utilities Engineer's Authorization

ONLY

- .6 Brother "P-Touch", portable electronic labelling system complete with self-adhesive, permanent printed labels with required nomenclature.
- .7 New panel and equipment names shall be approved by the Owner's Manager of Electrical Systems. U of T's Numbering System for Electrical Equipment on next page is for reference.



2.13 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;
 - .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 gasketting 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" standards for equipment specified as EEMAC/NEMA 1, 2 or 12.
- .6 Obtain CSA approval where required by local governing authorities.

2.14 ROOFTOP CONDUIT SUPPORT SYSTEM

- .1 Provide rooftop support systems with features as follows:
 - .1 CSA approved and/or ULC listed and labelled;
 - .2 non-penetrating of roof;
 - .3 vibration dampening;
 - .4 does not float;
 - .5 suitable for outdoor wet and freezing environments without damage caused by weather or freeze and thawing when exposed to de-icing chemicals;
 - .6 environmental friendly;
 - .7 constructed of recycled rubber.
- .2 Materials:

- .1 Base made of 100% recycled rubber and polyurethane pre-polymer with a uniform load capacity to suit specific load application of support (minimum 744 kg/m [500 pounds/linear foot]); each base to have a reflective red stripe.
- .2 Base: Dimensions: 150 mm (6") wide by 125 mm (5") tall by required overall length (minimum 225 mm [9"]); this is to be minimum dimensions, but base requirements must be increased to suit specific applications as recommended by system manufacturer; includes low base steel frame C channel 1.9 mm (14 gauge) – 25 mm (1") high strut galvanized per ASTM A653; and pipe roller assembly.
- .3 Attaching hardware: Zinc-plated threaded rod, nuts and attaching hardware per ASTM B633.
- .4 Conduit clamps: single pipe supports constructed of galvanized steel and sized to accommodate sizing of installed conduits.
- .3 Confirm with system manufacturer that selected products provide proper support for application.
- .4 Acceptable manufacturers are as follows:
 - .1 Cooper B-Line;
 - .2 Clearline Technologies (C-Port);
 - .3 Erico (Caddy Pyramid).

3 EXECUTION

3.01 GENERAL CONDUIT INSTALLATION REQUIREMENTS

- .1 Install conduit concealed in finished areas, and concealed to degree made possible by finishes in partially finished and unfinished areas. Conduit may be exposed in unfinished areas such as Electrical and Mechanical Rooms, unless otherwise noted on drawings or specified herein. Refer to and examine architectural drawings and room finish schedules to determine finished, partially finished or unfinished areas of building. Documents do not identify exact routing. Where shown, routing is diagrammatic, identifying general requirements of routing and locations. Include for necessary offsets, fittings, transformations and similar items required as a result of obstructions and other architectural or structural details not shown.
- .2 Where conduits are exposed, arrange them to avoid interference with other work, parallel to building lines and install as high as possible. Do not install conduits within 150 mm (6") of "hot" pipes or equipment unless conduits are associated with equipment. Independently run conduit to be supported from wall/ceiling structure, not from ceiling hangers, ductwork, piping, cable trays, formed steel decking, etc. Do not run conduits within 900 mm (3') of equipment access opening covers.
- .3 Conduits shall be installed so that the conductors can be drawn in without strain or damage to the conductors.
- .4 Conduits shall be installed to allow for expansion and expansion fittings shall be provided where required.

- .5 The use of running threads shall not be permitted. Ericson couplings shall be used where required.
- .6 Connectors for EMT conduit shall be steel, compression type, nylon insulated. Steel set screw type is acceptable.
- .7 A separate insulated ground wire shall be installed in all conduits, except computer/telephone/control conduits.
- .8 Conduits for computer systems shall comply with Enterprise Infrastructure Solutions (EIS) Standards.
- .9 So as not to impair required strength of structure, following criteria to be generally followed but which is to be reviewed and coordinated with Consultant prior to start of Work:
 - .1 where conduits pass by a column, stay at least two times thickness of slab and drop away from column;
 - .2 where conduits terminate adjacent to a column or wall, bring conduit in toward column/wall as close to 90° to face of column as possible within two times thickness of slab and drop away from column;
 - .3 maximum size of conduit in structural slabs is 1/5 of solid portion of slab thickness;
 - .4 where more than two conduits are adjacent to each other, they are to be spaced greater of 3 diameters or 100 mm (4") apart;
 - .5 total of depth of conduits crossing over each other is to be less than one-third thickness of slab;
 - .6 place conduit in middle third of thickness of slab; do not lay conduit directly on reinforcing steel;
 - .7 do not run conduit adjacent to parallel reinforcing bars;
 - .8 do not run conduit longitudinally in beam without approval of Owner and review with Consultant; pass through beams at right angles to span of beam;
 - .9 where conduits pass through beams, maintain at least twice depth of beam separation away from supports;
 - .10 do not run conduits in slab beside a drop or beam within twice depth of slab from edge of drop or beam;
 - .11 do not run conduits through shear walls or columns without approval of Owner and review with Consultant;
 - .12 do not place conduit in structural elements in parking garage structures, water retaining structures or structures subjected to de-icing chemicals, without approval of Owner and review with Consultant.
- .10 For proposed use of conduit runs underground below slab include following provisions:

- .1 concrete encased ductbank with conduits of non-ferrous materials and sloped to drain properly into pit;
 - .2 proper drain pit;
 - .3 system to be a pull-in system;
 - .4 20% spare conduits (with minimum of at least 1);
 - .5 system proposal to consider and address any effects of magnetic fields;
 - .6 joints in conduits shall be made completely watertight.
- .11 Minimum concrete thickness over or around a conduit in a concrete slab shall be 75mm (3").
- .12 For isolation rooms, seal conduits that penetrate through walls, floor, or ceilings with suitable elastomeric and intumescent materials around penetrating item and within any openings of item to ensure complete isolation of rooms. Such sealing materials are to be suitable for specific applications and maintain fire rating of penetrated surface and not be of a hazardous material. Submit shop drawings of proposed materials.
- .13 Conduits are sized on drawings, but in absence of type and sizing, type and size to suit intended application in accordance with applicable local governing electrical code requirements. Sizes identified on drawings are minimum sizes and are not to be decreased unless approved by Owner and reviewed with Consultant.
- .14 Where receptacle type devices are located in existing floors and/or where feeds are required to furniture systems in open spaces, and where chasing of floor slab to run conduit is not acceptable to Owner after review with Consultant provide fire rated "poke-thru" assembly installed through floor and feed from conduit runs provided in ceiling space of floor below.

3.02 INSTALLATION OF CONDUIT

- .1 Provide conduit for conductors except armoured cable and copper sheathed mineral insulated conductors, and except where duct or similar raceway materials are provided.
- .2 Provide conduit as follows:
 - .1 all conduits inside the building, including in ceiling plenums - EMT unless as noted below or elsewhere in this Specification;
 - .2 for interior building surface mounted services greater than 600 V – rigid threaded, galvanized steel conduit;
 - .3 for conduits exposed to the weather, in wet locations, subject to mechanical injury, or in any hazardous locations or where required by Cod – rigid galvanized steel (rigid PVC where permitted by local codes and Owner and reviewed with Consultant);
 - .4 for short branch circuit connectors to motorized equipment and distribution transformers (minimum length 450 mm (18"), maximum length 600 mm (24") with 180° loop where possible) – galvanized steel flexible liquid-tight conduit;

- .5 for motor feeder drops ahead of the flexible final connection to motor - rigid threaded galvanized steel conduit with a minimum 1m (3'-0") length and two additional clips over normal requirements. The minimum conduit size for the motor feeder drops shall be 19mm (3/4").
- .6 at points, where conductors cross building expansion joints – galvanized steel flexible conduit with no less than 600 mm (24") of extra curve;
- .7 for interior conduit above 50 mm (2") diameter containing distribution conductors or communication systems conductors (fire alarm, telephone etc.) (except as noted above) – EMT with separate insulated ground conductor.
- .3 Run rigid conductors in rigid type conduits suitable for application. Do not use flexible conduit.
- .4 Secure conduit located in poured concrete work in place in a manner such that conduit will not float or move when concrete is poured. Adequately protect such conduit from damage prior to and during concrete pour, and from concrete and water penetration.
- .5 Review with Consultant prior to Start of Work, maximum allowable size of conduit for installation in poured concrete. Placement of reinforcing steel in structural concrete work will take precedence over placement of conduit. Spaced adequately multiple runs of conduit in poured concrete work, as reviewed with Consultant.
- .6 Provide manufactured expansion joints in rigid PVC plastic conduit at spacing as recommended by conduit manufacturer.
- .7 Provide a separate ground conductor in plastic conduits.
- .8 Support and secure surface mounted and suspended single or double runs of metal conduit at support spacing in accordance with local governing electrical code requirements by means of galvanized pipe straps, conduit clips, ringbolt type hangers, or by other proper manufactured devices.
- .9 Support multiple mixed size metal conduit runs with Unistrut Ltd., Electrovert Ltd. "CANTRUSS" or Burndy Ltd. "FLEXIBLE" conduit racks spaced to suit spacing requirements of smallest conduit in group.
- .10 Unless otherwise noted, provide conduit fittings constructed of same materials as conduit and which are suitable in respects for application.
- .11 Provide proper adaptors for joining conduits of different materials.
- .12 Cut square and properly ream site cut conduit ends.
- .13 Provide conduit as sized on drawings. Size conduit not sized on drawings in accordance with latest edition of local governing electrical code with consideration that sizes of branch circuit conductors indicated are minimum sizes and must be increased as required to suit length of run and voltage drop in accordance with voltage drop schedule found on drawings or at end of this section. Where conductor sizes are increased to suit voltage drop requirements, increase scheduled or specified conduit size to suit. Unless otherwise noted on drawings or required by local governing electrical code or specified elsewhere, conduit to be of minimum size 13 mm (1/2") diameter. Structured network cabling system conduit to be of minimum 19 mm (3/4") diameter, unless otherwise noted.

- .14 Site made bends for conduit to maintain full conduit diameter with no kinking, and conduit finishes are not flake or crack when conduit is bent.
- .15 Plug ends of roughed-in conduits which are exposed during construction with approved plugs.
- .16 Ensure that conduit systems which are left empty for future wiring are clean, clear, capped and properly identified at each termination point. Provide end bushing and suitable fish wires in such conduits.
- .17 Provide empty conduits to ceiling spaces from flush mounted panelboards located below and/or near hung ceiling. Refer to drawing detail.

3.03 EXPANSION FACILITIES FOR CONDUIT CROSSING BUILDING EXPANSION JOINTS

- .1 Wherever concealed or surface mounted conduits cross building expansion joints, provide expansion facilities to permit free movement without imposing additional stress or loading upon support system, and to prevent excessive movement at joints and connections, in accordance with drawing details.

3.04 INSTALLATION OF OUTLET BOXES AND BACK BOXES

- .1 Provide an outlet box or back box for each luminaire, wiring device, telephone outlet, fire alarm system component, communications systems components, and each other such outlet.
- .2 Size boxes to accommodate exact supplied components and for bending radii of installed cables. Confirm requirements with respective system vendors.
- .3 Outlet boxes flush mounted in interior construction, surface mounted in concealed interior locations, and surface mounted in exposed interior locations where connecting conduit is EMT, to be stamped and galvanized steel outlet boxes unless otherwise noted.
- .4 Provide sealing around boxes in walls where insulation and vapour barrier is present or for walls of rooms that are sealed. Maintain sealing system of wall.
- .5 Outlet boxes in underground plastic conduit systems to be rigid PVC plastic outlet boxes, unless otherwise noted.
- .6 Outlet boxes for flush floor mounted devices to be concrete tight formed galvanized steel fully adjustable flush floor boxes. Locate in to position and install in accordance with manufacturer's instructions. Coordinate installation with trades pouring concrete floor slab or trade responsible for floor construction.
- .7 Provide a barriered outlet box for switches connected to normal and emergency power and share a common faceplate.
- .8 Provide outlet boxes for special wiring devices, for special equipment and special applications. Refer to requirements specified in other Sections and/or on drawings.
- .9 Mounting heights and locations for outlet boxes are typically indicated on drawings, however confirm exact location and arrangement of outlets prior to roughing-in. Architectural drawings and Consultant's instructions have precedence over electrical drawing diagrammatic layouts and specified mounting heights and locations.

- .10 Size and arrangement of outlet boxes to suit device which they serve.
- .11 Do not install outlet or back boxes "back-to-back" in walls and partitions. Stagger such outlets and seal against noise transmission in accordance with drawing details. "Thru-wall" type boxes will not be permitted for any application.
- .12 Provide blank coverplates on existing obsolete boxes which are to remain in position.

3.05 INSTALLATION OF PULLBOXES AND JUNCTION BOXES

- .1 Provide pullboxes in conduit systems wherever shown on drawings, and/or wherever necessary to facilitate conductor installations. Generally, conduit runs exceeding 30 m (100") in length, or with more than two - 90° bends, are to be equipped with a pullbox installed at a convenient and suitable intermediate accessible location.
- .2 Size boxes to accommodate exact supplied system and for bending radii of installed cables. Confirm requirements with respective system vendors.
- .3 Provide junction boxes wherever required and/or indicated on drawings and as required by local governing electrical code.
- .4 Provide sealing around boxes in walls where insulation and vapour barrier is present or for walls of rooms that are sealed. Maintain sealing system of wall.
- .5 Boxes in rigid conduit and EMT inside building to be stamped galvanized or prime coated steel.
- .6 Boxes in exterior rigid conduit and boxes in perimeter wall where insulation and vapour barrier is present, to be "Condulet" cast gasketed boxes, unless otherwise noted.
- .7 Boxes in plastic conduit to be rigid PVC plastic boxes complete with required couplings.
- .8 Pullboxes and junction boxes to be accessible after work is completed.
- .9 Clearly identify main pull or junction boxes by painting outside of covers. Spray painting is not permitted unless approved by Owner and reviewed with Consultant. Colour Codes to be in accordance with following table:

	System	Colour Code	Written Code
120/208V	-Normal lighting and power	White	
	-Emergency power	White / Red	
	-UPS	White / Blue	
240/416V	-Normal lighting and power	Pink	
	-Emergency power	Pink / Red	
	-UPS	Pink / Blue	
346/600V	-Normal lighting and power	Yellow	
	-Emergency power	Yellow / Red	
	-UPS	Yellow / Blue	

Fire Alarm	Red	
Telephone	Orange	
Cable TV	Purple	
Data	Brown	
Control	-HVAC	Green
	-L.V. Lighting control	Green / Black
Security	Grey	
Surveillance, CCTV	Grey / Black	
Public Address		"PA"
Audio Visual		"AV"
Paging		"PG"
Intercom		"ICOM"

Notes;

- .1 Light colours shall be chosen for Green, Blue, Brown, and Grey.
- .2 All junction box cover plates on various systems shall be colour coded according to the Table shown above.
- .3 Mark in black on the colour coded cover plates the year when this colour code was applied. Use 4-digit numbers to represent the year.
- .10 Cover boxes in fire walls with aluminium tape and seal with caulking.
- .11 Accurately locate and identify concealed pullboxes and junction boxes on "As-built" record drawings.
- .12 In addition to painting miscellaneous signal boxes, clearly identify specific system in which box is installed.

3.06 INSTALLATION OF DISCONNECT SWITCHES

- .1 Provide disconnects switches and install into locations and connect complete. Ensure adequate clearance is provided as per local code requirements and as required for access for operation and maintenance. Install as follows:
 - .1 wherever shown on drawings and/or specified herein;
 - .2 wherever required by MCC/VFD/starter schedule drawings;
 - .3 for motorized equipment which cannot be seen from motor starter location or is more than 9 m (30') from starter location (in accordance with local governing electrical code requirements);
 - .4 for "packaged" equipment fed from a motor starter panel.

- .2 Ensure enclosure ratings are suitable for intended applications.
- .3 Provide engraved Lamacoid nameplate with nomenclature reviewed with Consultant. The Lamacoid shall reference the upstream protection device's panelboard, circuit, and room number.

3.07 INSTALLATION OF NEW BREAKER IN EXISTING SWITCHGEAR

- .1 Contact the manufacturer of the existing switchgear so that new air circuit breaker will fit in the existing empty cell.
- .2 Install new breaker as per manufacturer's recommendations.

3.08 INSTALLATION OF FIRESTOPPING AND SMOKE SEAL MATERIALS

- .1 Where electrical 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. Submit to Consultant, copies of certificates of compliance from an independent testing agency, attesting that fire stopping and smoke seal materials meet ULC requirements. Openings not in immediate vicinity of working areas are to be firestopped and sealed same day as being opened.
- .2 Examine condition of voids to be filled to ensure suitability for systems. Verify installation of service penetrations and adjacent construction has been completed. Prepare substrates and surfaces to a clean, dry, frost-free condition, and primed to firestop system manufacturer's recommendations to receive firestopping system.
- .3 Install fire stopping 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 that 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 fire stopping materials.
- .4 Ensure that 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".
- .5 Where work requires removal of existing firestopping materials and replacement of firestopping materials after cabling changes have been made, ensure that replacement material is same material and manufacturer of existing if any remains in place, or ensure that all existing material is removed before installation of replacement material.
- .6 After installation work is complete, arrange for 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.

3.09 INSTALLATION OF FASTENING AND SECURING HARDWARE

- .1 Provide fasteners and similar hardware required for conduit, duct, raceway, conductors, etc. and for equipment hanger and/or support material unless otherwise noted.

- .2 Accurately and properly set concrete inserts in concrete framework. Where multiple type inserts are used, space same to suit requirements of smallest conduit, etc., in group.
- .3 Fasten hanger and support provisions to masonry with expansion shields and machine bolts, or, for light loads, use plugs, and screws.
- .4 In drywall or plaster walls and/or ceilings use two wing toggles and for heavy loads, provide steel anchor plates with two or more toggles to spread load.
- .5 Provide beam clamps for attaching hanging and/or support provisions to structural steel, or where approved by Owner and reviewed with Consultant, weld hanging and support provisions to structural steel.
- .6 Explosive powder actuated fasteners are not permitted unless specific written approval for their use and type has been obtained from Consultant.
- .7 Under no circumstances use ceiling suspension hangers or grids for suspension of conduit and conductors. Install supports to permanent structure of building, limited to areas that will not damage structural stability.
- .8 Comply with Structural Engineer's limitations for maximum penetrations of securing hardware into concrete slabs.

3.10 INSTALLATION OF ROOFTOP SUPPORT SYSTEM

- .1 Install rooftop support system for conduits/raceways in accordance with manufacturer's instructions and recommendations to suit type of raceway and roofing materials.
- .2 If gravel top roof, remove gravel from around and under pipe support. Coordinate work with building roofing vendor confirmed with Owner and reviewed with Consultant.
- .3 Consult existing roofing vendor for roof membrane compression capacities and roof loading limitations. Comply with restrictions.
- .4 Use properly sized clamps to suit conduit sizes. Ensure that installation and use of system does not invalidate existing roof warranties.
- .5 Engage existing roofing vendor to inspect installation and verify that installation has not damaged roof.

3.11 BRANCH CIRCUIT BALANCING

- .1 Connect branch lighting and power circuits to panelboards so as to balance actual loads (wattage) within 5%. If required, transpose branch circuits when work is complete to meet this requirement.
- .2 At request of Consultant, perform necessary tests to show compliance with above requirement. Make such tests after building is occupied.

3.12 ELECTRICAL CONNECTIONS FOR MECHANICAL, OWNER'S, ETC., EQUIPMENT

- .1 Provide required electrical connections to apparatus provided and/or supplied by Electrical Divisions. Review shop drawings and coordinate with each equipment vendor, requirements for power feeds and control/communication interconnections and provide these requirements to complete installations work.

- .2 In addition to providing electrical feeders and connections to equipment provided by Electrical Divisions, provide required electrical connections to apparatus provided and/or supplied by Mechanical Divisions, Owner and as part of other Divisions.
- .3 Unless otherwise noted, provide electrical connections including power and control wiring for equipment supplied by Owner or by other Divisions, and except where specified for control wiring of Mechanical Divisions automatic control systems specification Section. Provide complete wired and empty conduit systems with fish cord, junction boxes, pull boxes, outlet boxes, faceplates, sleeves, etc. Provide disconnect switches, receptacles and other required wiring and connection accessories. Coordinate work with respective Consultants and suppliers of equipment to be provided with electrical connections.
- .4 Refer to Division 11, and include for coordination and interconnections of Division 11 requirements and equipment schedule.
- .5 All mechanical control loads shall be fed from the same source of power supply as the equipment it is controlling, as per U of T Standards. When a device controls multiple pieces of equipment fed from different sources, the control load shall be powered from an emergency supply via a UPS.
- .6 Coordinate with trades of other Divisions to ensure provision of proper electrical requirements. Unless otherwise noted or reviewed with Consultant, be responsible for provision of interconnect wiring between remote operator devices, controllers, and equipment being controlled by operator devices, whether or not such devices/controllers are supplied by Electrical Divisions. Where equipment is of split unit design and line voltage is required to both units, be responsible for feeders to each unit as coordinated with equipment manufacturer and Division responsible for equipment. Provide disconnect switches, receptacles and other required wiring and connection accessories. Provide system/equipment power feeds with hard wired or receptacle type connections, as required. Coordinate exact requirements prior to start of work, at time of shop drawing submissions and prior to roughing-in of work. Coordinate work with suppliers of equipment to be provided with electrical connections which may include but not be limited to following:
 - .1 Owner's equipment;
 - .2 telecommunication systems;
 - .3 mechanical systems and equipment.
- .7 Provide coordination of alarm connections of equipment with Mechanical Divisions BAS Contractor. Refer to drawings of both Electrical Divisions and Mechanical Divisions for BAS points to be connected. Include for wiring in conduit, contacts, termination/junction boxes, etc., as required for inter connection.
- .8 Mechanical Divisions are responsible for supply of motor starters and variable frequency drives (VFDs) (also known as variable speed drives –VSDs) and harmonic filters for motorized apparatus supplied by them and is to provide Lamacoid identification throughout. The Lamacoid shall reference the upstream protection device's panelboard, circuit, and room number. Motor starters, VFDs and/or MCCs are generally to be as scheduled. Generally starters are supplied in following manner:
 - .1 loose starters for mounting adjacent to apparatus or on motor starter panels;
 - .2 mounted starters in factory assembled and pre-wired motor control centres;

- .3 mounted starters on factory assembled and pre-wired packaged equipment.
- .9 VFDs are to be supplied and set in position by Mechanical Divisions, all equipped with line side passive harmonic filters per U of T Standards.
 - .1 VFD shall be equipped with a local disconnect switch, lockable in the open position. A means of visual confirmation of isolation of the conductors shall be provided when in the open position.
 - .2 Coordinate installation and connection requirements with Mechanical Divisions and respective equipment manufacturers.
 - .3 Voltage total harmonic distortion (THD) shall not exceed 5% THD (V) at the point of common coupling. Total demand distortion (TDD) shall not to exceed 5% of the total full load fundamental current (I).
 - .4 Obtain required wiring diagrams.
- .10 Be responsible for following work:
 - .1 mounting loose starters and providing "line" and "load" power connections;
 - .2 making "line" side power connections to panelboards and "load" side connections to motors;
 - .3 making "line" side power connections to starters on "packaged" equipment;
 - .4 coordinating feeder entries to starters and starter assemblies with Mechanical Divisions;
 - .5 providing additional disconnect switches (complete with identification) detailed on drawings, or required by Code, or for apparatus which cannot be seen from its starter or is in excess of 9 m (30') from its starter;
 - .6 connections to thermistors and provision of additional relays as required for connections to starters; generally, Mechanical Divisions are to supply required thermistors and relays necessary for starters; review Mechanical Divisions specifications and/or drawings defining these requirements and include necessary work, wiring, conduit and components not being supplied by Mechanical Divisions;
 - .7 performing required motor starter interlocking in accordance with requirements specified and as outlined on starter schedules; coordinate interlocking requirements with Mechanical Divisions;
 - .8 ensure that an identification nameplate is provided on each motor starter or disconnect. The Lamacoid nameplate shall reference the upstream protection device's panelboard, circuit, and room number;
 - .9 ensure that an identification nameplate is provided on each disconnect switch nameplate is to identify name and voltage;
 - .10 ensure that an identification nameplate is provided and attached with stainless steel screws to each separately mounted 3-phase motor starter or group of 3-phase motor starters a suitably sized black-white-black Lamacoid nameplate engraved to read:

"MOTOR(S) IS CAPABLE OF MAKING TWO (2) STARTS IN SUCCESSION, COASTING TO REST WITH APPROXIMATELY 15 MINUTES ELAPSED TIME BETWEEN STARTS, WITH MOTOR INITIALLY AT AMBIENT TEMPERATURE, OR OF MAKING ONE (1) START WITH MOTOR INITIALLY AT A TEMPERATURE NOT EXCEEDING ITS RATED LOAD OPERATING TEMPERATURE, IF ΩK^2 OF LOAD, LOAD TORQUE DURING ACCELERATION, APPLIED VOLTAGE AND METHOD OF STARTING ARE THOSE FOR WHICH MOTOR WAS DESIGNED."

- .11 Where supplied by Mechanical Divisions and connected by Electrical Divisions, connect VFDs and harmonic filters in strict accordance with manufacturer's instructions. Provide manufacturer's recommended conductors and connectors to suit respective connected equipment. Provide required upstream fused disconnects or breakers and overload protection. Maintain separation of power and control conductors as per manufacturer's requirements to minimize effects of electromagnetic interference. Properly ground and bond equipment. Coordinate exact installation requirements with Mechanical Division and equipment vendors.

3.13 DISCONNECTION, REMOVAL AND RELOCATION WORK

- .1 Where indicated on drawings or where required to perform Work of this Project, disconnect and remove items of existing obsolete electrical work. Relocate required devices as required to accommodate work of other Divisions. Where luminaires, switches, receptacles, and other devices and/or equipment is removed, disconnect at point of electrical supply, remove obsolete wiring and conduit up to source, unless otherwise noted, and make system safe to Owner's satisfaction and as reviewed with Consultant. Remove obsolete conduit/raceways in accessible ceiling spaces, exposed locations, etc. Where existing obsolete conduit and similar raceway material cannot be removed, such as embedded in concrete, cut back and cap obsolete conduit and raceways. Refer to specific notes on drawings.
- .2 When respective work is deleted, such deletions are to in no way affect operation of any existing interconnected mechanical or electrical components that remain. When existing circuits are being disconnected, maintain supervision of area to ensure that such circuits do not affect essential existing circuits being retained.
- .3 Refer to architectural drawings which define extent of areas being demolished in existing building. Review drawings and site and include for demolition and/or renovation of services as required to accommodate alterations detailed.
- .4 Unless otherwise noted, obsolete materials which are removed and are not to be relocated or reused are to become your property. Remove from site and properly dispose. Obtain from Owner and coordinate with Consultant, a list of existing electrical items which are to be removed and turned over to Owner. Said items are to remain property of Owner.
- .5 Where existing services pass through or are in an area to serve items which are to remain, or pass through areas that are to be deleted, maintain services, but re-route as required. 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. Confirm with Owner services which are to be kept in service and operational.
- .6 Revise panelboard directories accordingly, if affected by any renovation, disconnection, or removal of work. Use Owner's actual room names/numbers. Provide newly printed directories to U of T Standards. Handwritten markups are not acceptable.

- .7 Protect existing devices being relocated or deleted to ensure that they are not damaged. Test such devices prior to disconnection and de-energization, to ensure that each device is in proper working condition. Ensure that motors are in proper rotation direction. Examine each device for damage. Report devices not working or with damage to Consultant prior to initiating any work. It will be assumed that devices are in proper working order and good condition if not reported.
- .8 Provide junction boxes, outlet boxes, wiring, plates, etc., as necessary for complete relocation of devices. Clean relocated or temporary removed devices and equipment, and ensure that they are in good operating condition before being reinstalled. Where existing luminaires are relocated, clean luminaires and inspect for damage. Relamp relocated luminaires. Report defects or damages to Consultant. Do not splice conductors unless approved by Owner and reviewed with Consultant. Utilize junction boxes and terminal devices for proper extension of circuits where approved. Otherwise replace circuits with home run continuous run of suitable lengths.
- .9 Provide blank coverplates on existing obsolete boxes which are to remain in position.
- .10 After installation is complete, test parts of re-used or relocated electrical equipment and correct faults and grounds. Include for fire alarm verification company to verify any relocated devices and downstream affected devices, and verify system as required by local fire authority to suit actual relocation work. For other existing systems, engage manufacturers authorized representative or Owner's system maintenance contractor, to inspect and verify relocated devices. Coordinate and confirm exact requirements with Owner and/or Consultant. Document testing in test reports, signed by testing technician. Submit copies to Consultant.
- .11 Interior, exterior or underground electrical services (including auxiliary services, telephone, fire alarm, P.A. System, etc.) to operating parts of building are not to be hampered under any conditions and to that effect, necessary work may have to be carried out on an overtime basis, at no additional cost to this project. Existing risers are to be maintained in service as required to feed other areas of building(s). Do not interrupt any services without prior written approval by Owner and reviewed with Consultant. Submit formal requests to Consultant outlining in detail requirements of proposal and wait for instructions from Consultant.
- .12 Be present when new doors or openings are being cut into existing walls and ceilings. Should any damage occur to electrical system, restore system to a safe and sound condition.
- .13 Where references are made on drawings that existing receptacles, etc., be extended and/or relocated to suit new construction, receptacles, etc., are to be tested and if found defective, be replaced with new devices. Cracked or broken cover plates are to be replaced and match Architectural finishes. Contractor may optionally replace existing basic receptacles, switches, and faceplates with devices matching existing devices.
- .14 Be responsible for disconnecting power supply to branch circuits controlling lighting, receptacles, panels, mechanical equipment, etc., for safe removal of equipment, conduit, wiring, boxes, etc., affected by demolition.
- .15 Close openings in boxes, panels, etc., that result from removal of equipment, conduit, wiring, fixtures, etc. Close openings in a proper manner and properly terminate and insulate cables to restore system to a safe operating condition, to Consultant's satisfaction.

- .16 Be present and supervise removal of electrical equipment, P.A. speakers, etc., during demolition of ceilings, walls, floors, etc. Existing equipment which is not to be relocated but interferes with demolition, are to be temporarily relocated until demolition work is completed. Services to temporarily relocated equipment are to be maintained at all times.
- .17 Remove and re-install existing ceiling tiles as required to perform work. Prior to removal, inspect tiles for damage and report any to Owner and Consultant. Any loose cabling is to be secured, and luminaires additionally supported with cables secured to ceiling slab. After work has been completed and successfully inspected, re-install ceiling tiles to existing standards and re-install devices. Be responsible for replacement of tiles and grid members damaged during work of Electrical Division. Comply with applicable governing authority requirements with regards to ceiling work in special areas.
- .18 Where existing surfaces are damaged by Electrical Divisions work and/or where existing devices are removed from wall, ceilings, floors and other surfaces, and such deleted devices are not being replaced in same locations, patch locations of these removed devices and re-finish. Patching and finishing is to be provided by tradesmen skilled in particular trade or application worked on, to Consultant's approval. Where openings are left in existing ceiling tiles, replace ceiling tiles with new matching tiles approved by Consultant. Unless otherwise included for in other Divisions, include for:
 - .1 preparing existing surfaces to be filled and repainted to be cleaned as required to remove dirt, dust, oil, grease, loose paint, rust and any other foreign matter which would prevent proper bonding of new finish; sand glossy surfaces to uniform dull texture;
 - .2 filling in and patching surfaces with same material as existing surfaces; finished surfaces to match and line with existing adjoining surfaces;
 - .3 providing fire stopping materials to maintain fire rating of the existing surfaces; refer to specification article entitled - Firestopping and Smoke Seal Materials.
 - .4 using paint rollers and/or brushes to apply and extend paint finish over full height and/or width of area affected, to a straight line in location determined by Consultant;
 - .5 applying sufficient number of coats such that patched area is indistinguishable to surrounding area;
 - .6 materials used to be of equivalent quality to existing finishes standards and be compatible with finishes to which they are applied;
 - .7 finishes to be approved by Owner and reviewed with Consultant.
- .19 Check luminaires to be deleted for PCB ballasts. Disconnect and remove such ballasts. As specified previously, include for company specialized in such hazardous materials to remove and dispose such materials off-site in compliance with Ministry of Environment, Ministry of Transport and any other governing authority regulations.
- .20 If at any time during course of building work, asbestos containing materials are encountered or suspected, cease work in area in question and immediately notify Consultant. Comply with local governing authority regulations. Do not resume work in affected area without approval from Consultant.

3.14 INTERRUPTIONS TO AND SHUT-DOWNS OF SERVICES AND SYSTEMS

- .1 Shutdowns and interruptions to existing systems and services are to be coordinated fully with and performed at times acceptable to Owner and reviewed with U of T Facilities & Services (F&S). For submission requirements of a shutdown Request, refer to Article 1.05 in this Section.
- .2 Generally, shutdown may be performed only between hours of 12:00 midnight Sunday 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.
- .3 Upon award of contract, submit to Consultant for review and approval, a list of anticipated shut-down times and their maximum duration.
- .4 Prior to each shut-down or interruption, inform Consultant and Owner in writing 10 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 written consent. Note that shutdowns of some essential services may require additional advance notification time.
- .5 Work associated with shut-downs and interruptions are to be carried out as continuous operations to minimize shut-down time and to reinstate systems as soon as possible. Prior to any shut-down, ensure that materials and labour required to complete work for which shut-down is required are available at site.
- .6 Where working in close proximity to "live parts" or inside energized panels or energized cubicles of switchboards/substations, provide protection "boots" over bussing and insulating mats to cover areas of exposed live parts.

3.15 EQUIPMENT BASES AND SUPPORTS

- .1 Provide equipment bases, supports and concrete housekeeping pads for mounting of floor standing equipment.
- .2 Secure floor mounted equipment in place on 100 mm (4") high concrete housekeeping pads, 100 mm (4") wider and longer than equipment base dimensions. Chamfer edges of bases.
- .3 Supply dimensioned drawings, templates, and anchor bolts for proper setting of equipment on bases and pads. Be responsible for required levelling, alignment, and grouting of equipment.
- .4 Submit to Consultant for review, dimensioned shop drawings of structurally designed concrete pads or bases for support of large, heavy equipment. Indicate on shop drawings total weight of pad or base, reinforcement, and equipment for which it is required.
- .5 Unless otherwise noted, support equipment suspended above floor level with suitable welded or bolted prime coat painted structural steel angles or channels bracketed to wall or secured by hanger rods.

3.16 CUTTING, PATCHING AND CORE DRILLING

- .1 Unless otherwise provided by General Trades, perform cutting, patching, and core drilling of existing building required for installation of your work. Perform cutting in a neat and true fashion, with proper tools and equipment. Patching is to exactly match existing finishes and be performed by tradesmen skilled in particular trade or application. Work is subject to review and acceptance by Owner and Consultant.
- .2 Criteria for cutting holes for additional services:
 - .1 cut holes through slabs only; no holes to be cut through beams;
 - .2 cut holes 150 mm (6") diameter or smaller only; obtain approval from Structural Consultant for larger holes;
 - .3 keep at least 100 mm (4") clear from beam faces;
 - .4 space at least 3 hole diameters on centre;
 - .5 for holes that are required closer than 25% of slab span from supporting beam face, use cover meter above slab to clear slab top bars;
 - .6 for holes that are required within 50% of slab span, use cover meter underside of slab to clear slab bottom bars;
 - .7 submit sleeving drawings indicating holes and their locations for Structural Consultant's review.
- .3 Where conduits and/or conductors penetrate existing construction, core drill or saw cut an opening. Size openings to leave 13 mm (1/2") clearance around conduit and/or conductors, and pack and seal and void between opening and conduit and/or conductor for length of opening with ULC listed and labelled material in accordance with article entitled "Firestopping And Smoke Seal Materials" specified herein this Section.
- .4 Do not cut or drill any existing work without approval of Owner and coordination with Consultant. Be responsible for damage done to building and services caused by cutting or drilling.
- .5 Prior to drilling or cutting an opening, determine, in consultation with Consultant and Owner, and by use of non-destructive radar scan (magnetic scan) of slab or wall, presence of any existing services and reinforcement bars concealed behind building surface to be cut and locate openings to suit. Be responsible for damage to existing services caused by core drilling or cutting openings. Coring is not permitted through concrete beams or girders.
- .6 Fire stop and seal openings as specified, and patch as required before end of workday. No openings are to be left open overnight unless approved by Owner and coordinated with Consultant.

3.17 CONDUIT PROVISIONS FOR MISCELLANEOUS SYSTEMS

- .1 Provide following components to accommodate future installation of various miscellaneous systems by system installers who are to provide equipment and wiring:

- .1 conduit - diameters as sized on drawings with non-metallic fish wires or pull cords and suitable bushings for conduit terminations, and as specified in Part 2; provide labelling at each end to clearly identify each conduit run with respect to system and path;
- .2 outlet boxes - standard galvanized steel, each complete with a blank type faceplate, and as specified in Part 2;
- .3 pull boxes, junction boxes, back boxes and sleeves - and as specified in Part 2.
- .2 Miscellaneous systems are typically as shown on drawings. Unless otherwise noted on drawings, provide dedicated conduit runs for each system. Coordinate sizes of boxes with respective system vendors to ensure proper sizing to accommodate components and that allows for wiring bending radii. Confirm conduit and box requirements also with system vendors.
- .3 Provide pullboxes in conduit runs longer than 30 m (100') or having more than two - 90 bends. Size pullboxes to be at least 8 times entering conduit in length. Pullbox sizes to comply with respective system standards.
- .4 Leave conduits free and clear of all obstructions and terminate as required. Equip terminations with bushing, and clearly identify each run. Provide fish wires in all empty conduits. Run telecommunications conduits to comply with separation from sources of electromagnetic radiation as per standard ANSI/TIA/EIA-569. Site bend telecommunications conduit elbows to comply with system conduit bending radii requirements.
- .5 Confirm exact requirements and locations of equipment with Consultant and respective system installers prior to roughing-in.
- .6 Refer to system riser diagrams on drawings.
- .7 Quantities for outlets to be as per floor plan drawings and not riser diagrams.

3.18 DOOR HARDWARE

- .1 Generally, Division 08 or another Division not under scope of electrical Contractor, is responsible for supply and installation of door alarm contacts, door holders, electric strikes, electromagnetic locks, door operator controls, power supplies, door controllers, central electromagnetic lock release controller and other door hardware. Coordinate and confirm with General Trades Contractor and respective equipment vendors (door hardware / security) exact responsibility of each Division of the Work.
- .2 Confirm product and wiring requirements, back box requirements and wiring installation requirements with door hardware trades and with equipment vendors. Provide required wiring in conduit from each device to respective controllers, between each device, and to central control panel and for power connection to such controls and devices. Provide line level voltage power feeds to equipment as required.
- .3 For controls and interconnections between devices, when such device terminations are responsibility of others, supply and run interconnecting wiring in conduit to devices and allow spare length of 1.8 m (6') coiled wiring at each end for final termination to devices by others.

- .4 Exact type of door alarm contacts to be coordinated with door construction and finishes. Contacts to generally be recessed mounted and wiring be installed in concealed conduits. Confirm exact requirements with door hardware / security vendor and General Trades Contractor.
- .5 Where controls are located remotely from door locations, such as in closets, provide wiring in conduit and extend from local above door junction boxes and devices as required with homeruns back to closet location of equipment and leave slack wiring for terminations by others. Confirm exact requirements with door hardware / security vendor and General Trades Contractor.

END OF SECTION

1 GENERAL

1.01 OVERVIEW

- .1 Maintain all electrical services to all parts of the site which are to remain in use. Electrical Contractor shall schedule all work and inform the owner in writing at least one week in advance for permission if power shutdown is necessary and state time(s) and duration(s) of interruptions. Contractor to consult with the Owner and determine the equipment required to be on line 24 hours per day and provide temporary services and wiring as necessary. Reschedule work accordingly when requested by the Construction Manager and/or Owner.
- .2 Include cost of premium time in tender price for work during nights, weekends or other time outside normal working hours necessary to maintain all electrical services in operation.

1.02 SCOPE OF DEMOLITION

- .1 Work shall include for removal, and/or reinstallation of electrical devices, feeders and equipment in the areas noted on the drawings.
- .2 Where existing power distribution equipment, wiring devices, power connections and/or lighting fixtures shall be removed as design required, its dedicated power feeders / circuits shall be cut back to the source of supply, unless otherwise as indicated on the design drawings.
- .3 Any existing electrical conduit and boxes, if not to be re-used for final installation, shall be removed. At completion of demolition, there shall be no abandoned services in the ceiling of the space.
- .4 Existing data and voice cables, which are no longer required, will be pulled back to source and to be disposed. Associated electrical conduit and boxes shall be removed if not to be re-used for final installation.
- .5 Where any existing branch panel is to remain, but its branch circuit(s) is (are) removed / modified, the panel directory shall be updated according to electrical demolition works, using U of T standard panel schedule templates. Download templates from website of the University of Toronto facilities & services.
- .6 Furnish all labour, materials, equipment, transportation, services, facilities and supervision necessary to demolish and dispose of all equipment, systems and materials specified herein and on the drawings.

1.03 DISPOSAL OF MATERIALS

- .1 All material removed from the site shall be disposed of in accordance with all applicable environmental legislation and regulations and as noted elsewhere in the specifications.
- .2 Separate and recycle materials to be disposed to the maximum extent possible.

1.04 HAZARDOUS MATERIALS

- .1 Review the Designated Substances and Hazardous Building Materials Assessment prior to commencement of work.

- .2 If at any time during course of work hazardous materials are encountered or suspected, cease work in area in question and immediately report, in accordance with Ontario Regulation 654/85 (Section 7) to Construction Manager. Do not resume work in affected area without approval from Construction Manager.

2 PRODUCTS

2.01 NIL

3 EXECUTION

3.01 REMOVAL OF MATERIALS

- .1 All workers shall be competent in, and trained to perform, the tasks that they perform. Where applicable, workers shall be licensed or otherwise qualified for the tasks that they perform
- .2 Remove from site all demolished equipment and materials. All material to be removed shall become the property of the contractor for Division 26.
- .3 No equipment may be burned on site or sold on site.
- .4 The contractor for Division 26 shall remove material in a manner so as to not destroy the existing to remain structure or exterior.
- .5 All lighting to be re-installed shall be cleaned so that no asbestos containing material remains. Coordinate with general and abatement contractors to eliminate any cross contamination of asbestos containing material.
- .6 Protect all removed (to be retained) equipment from damage. Repair or replace without adjustment to the contract price all existing equipment which is damaged in process of reinstallation.
- .7 While removing cables / circuit wires, associated conduits shall also be fully removed, except for any portion that falls within an asbestos area or is embedded in concrete.

3.02 SYSTEMS TO REMAIN

- .1 All services and equipment not shown as to be removed on drawings shall be maintained in operation during the construction phase. The contractor for Division 26 shall be required to provide new conduit and wiring for all existing systems to remain where the existing conduit and cabling interferes with the demolition work. Contractor for Division 26 to temporally remove existing devices and reconnect to existing system at new location as needed / as indicated to maintain the function of existing devices that to remain.
- .2 All existing panel directories on all panels affected by this Contract shall be retyped to indicate existing services remaining, spares, spaces and new services connected to same. The updated panel directories shall use UofT standard panel schedule templates. Download templates from link "[The University of Toronto's design standards and project forms](#)".
- .3 Maintain operation of all systems outside of the demolished area which may be affected by the demolition.

- .4 Any circuits which have been made inoperative as a result of this work but are not in an area to be demolished shall be reactivated at no cost to the Owner.
- .5 Trace out and catalogue all circuits within the scope of demolition and adjacent areas. Mark this information on a set of drawing prior to any work commencing as these circuits will be maintained as part of this work as noted on the drawings.
- .6 Clean and test existing equipment which is to remain and equipment being reinstalled in areas being renovated for proper operation and repair as necessary before being put back into service.
- .7 Contractor for Division 26 to verify operation of all existing devices and report any discrepancies to the Construction Manager, Architect and Engineer prior to proceeding with the work.
- .8 Unless noted otherwise provide additional equipment of the same type and manufacture where required to supplement existing equipment.
- .9 Clean and inspect all existing panels to be reused and report any defects to the Construction Manager, Architect and Engineer prior to starting the work. Perform thermographic survey of all existing panels to be reused and/or modified.

END OF SECTION

1 GENERAL

1.01 SUBMITTALS

- .1 Submit shop drawings for products and accessories.

2 PRODUCTS

2.01 GENERAL POWER CABLES

- .1 CSA approved, ULC labelled and certified. Unless otherwise noted, conductors to be copper and be suitable for applications as noted in governing local electrical code. ALUMINUM CONDUCTOR CABLES SHALL NOT BE USED.
- .2 "RW90" CSA certified, single copper conductor to CSA C22.2 No. 38, 600/1000 volts, maximum 90°C (194°F) conductor temperature, -40°C (-40°F) minimum installation temperature, X-link polyethylene (XLPE) insulation, colour coded.
- .3 "T90 Nylon", CSA certified, single copper conductor to CSA C22.2 No. 75, 600 volts, maximum 90°C (194°F) dry conductor temperature, -10°C (-14°F) minimum installation temperature, PVC insulated, nylon covered.
- .4 "TWU" single copper conductor to CSA C22.2 No. 75, 600 volts, maximum 60°C (140°F) conductor temperature, -40°C (-40°F) minimum installation temperature, PVC insulated suitable for wet and buried installations, colour coded.
- .5 "RWU90" CSA certified, single copper conductor to CSA C22.2 No. 38, 1000 volts, maximum 90°C (194°F) conductor temperature, -40°C (-40°F) minimum installation temperature, extra thickness X-link polyethylene (XLPE) insulation suitable for wet and buried installations, colour coded.
- .6 "AC90" flexible armoured cable with "RW90" conductors and bare copper ground conductor and overall interlocked aluminium tape armour, to CSA C22.2 No. 51 (R2004). This is allowed for a maximum of 1m (39 in) final connection to a motor termination enclosure.
- .7 Solid conductors to and including No. 10 AWG; stranded conductors in sizes larger than No. 10 AWG; branch circuit conductors constructed of 98% conductive copper; and approved for minimum 600 volts.

2.02 WIRING CONNECTIONS

- .1 Armoured cable connectors must be proper squeeze type connectors and plastic anti-short bushings at terminations.
- .2 Connectors for conductors connecting to devices as per local governing electrical requirements to be equal to IDI Electric (Canada) Ltd., "Ideal" No. 451, No. 452 and No. 453, "Wing-Nut", CSA certified, 600 volts, rated pressure type connectors.
- .3 For conductors sized 3/0 and greater, provide long barrel double crimp, 2 hole compression type lug connectors, unless otherwise noted.
- .4 Type "MI" cables shall be terminated with moisture proof connectors.

- .5 No splices shall be installed on any low voltage feeders.
- .6 Terminals and terminations not designed for multiple connections shall only have a single current-carrying conductor landed.
- .7 All devices will be terminated with the recommended torque as specified by the manufacturer. Consult with the university if no torque specification is available.

2.03 FIRE RATED CABLES

- .1 Pentair - Pyrotenax, model "System 1850", CSA certified, ULC listed and labelled, FM Specifications tested, 600 V, type "MI", 2 hour fire rated, solid copper conductor, copper sheathed with a protective jacket where required, highly compressed magnesium oxide mineral insulated power cable. Connectors for copper-sheathed mineral conductors to be cable manufacturer's proper connectors and accessories as recommended by manufacturer to suit specific applications.
- .2 Pentair - Pyrotenax, model "System 1850 Twisted Pair", CSA certified as FAS, FAS 90 and FAS 105 cable, ULC listed and labelled, 300 V, type "MI", 2 hour fire rated, copper sheathed, copper conductor, highly compressed magnesium oxide mineral insulated fire alarm and voice communication cable. Connectors for copper-sheathed mineral conductors to be cable manufacturer's proper connectors and accessories as recommended by manufacturer to suit specific applications.
- .3 Manufacturer's termination kits: Pyropak epoxy sealing compound kits and "Quick Term" connectors; connectors for MI conductors to be cable manufacturer's proper connectors and accessories as recommended by the manufacturer to suit specific applications.
- .4 Cable clips and straps as recommended by cable manufacturer to suit specific installation application. In applications of dissimilar materials, provide tape to insulate cabling and hardware.
- .5 Brass plates for cable openings in ferrous metal enclosures.
- .6 Include for required cable manufacturer's accessories and identification labelling.
- .7 Typically splices are not permitted, but where required, use of factory or field splices to be approved by Consultant. Refer to drawings for general locations of routing of cables and specific locations of field splices. . For applications where splicing is not identified as a requirement, factory splicing when approved by Consultant may be provided based on manufacturer's review of routing and length of onsite runs. Field splicing when approved by Consultant, to be performed by electricians trained by cable /splice manufacturer.
- .8 Manufacturer's splice kit – ULC listed, 2 hour fire rated, welded splice for MI cables; temperature rating of 1010°C (1850°F); stainless steel cones at each end of cupro-nickel barrel, and splice boxes
- .9 Include for manufacturer's authorized technician to be present on site for initial coordination with installing personnel on review of proper installation of cabling runs, termination of cabling and making splices. Manufacturer's technician to be also onsite to witness splicing work. After completion of Work, manufacturer's technician to review installation and splicing work and provide in writing that splicing and installation work has been performed to satisfaction of cable manufacturer.

- .10 Acceptable manufacturer of fire rated MI type cables is nVent Pyrotenax.

2.04 STANDARD CONTROL AND COMMUNICATIONS CABLES

- .1 ULC listed and labelled, CSA certified to C22.2 No. 127, No. 18 AWG "TEW" thermoplastic insulated, solid copper wire rated for 600 volts service, and 105°C (220°F) conductor temperature, complete with required number of copper conductors and colour coding.

2.05 CONDUCTOR PULLING LUBRICANT

- .1 IDI Electric (Canada) Ltd., "Ideal Yellow 77" or "Wire Lube" as required.

2.06 CORFLEX CABLES

- .1 CSA type "RA90" (X LINK) conductors, Nexans Corflex II cable suitable for 600 volt service and consisting of cross linked polyethylene insulated single copper conductors, 90°C (194°F) rated, enclosed by a continuous extruded corrugated aluminum sheath with an overall PVC jacket.
- .2 Acceptable manufacturers are:
 - .1 Nexans;
 - .2 Prysmian Cables (Pirelli);
 - .3 General Cable;
 - .4 Aetna Cables;
 - .5 Kerite Company.

2.07 TECK CABLES

- .1 Nexans, "Firex II Teck" cables as follows:
 - .1 certified to CAN/CSA C22.2 No.131, Type TECK 90 Cable;
 - .2 rated for outdoor, weather resistant and wet locations applications;
 - .3 600/1000 V rated;
 - .4 Conductor: Bare, Soft drawn, Class B Compact or Compressed Stranded Copper conductors per ASTM;
 - .5 insulation: chemically cross linked thermosetting polyethylene (XLPE);
 - .6 bonding conductor (1/C Cable): Soft drawn bare copper;
 - .7 inner jacket: sunlight resistant PVC jacket tightly applied over assembly, to prevent slipping of core in a vertical position;
 - .8 armour: flexible interlocked aluminum armour, over inner jacket for mechanical protection;
 - .9 overall PVC jacket rated -40°C (-40°F).
 - .10 barrier tape over shield.

.2 Acceptable manufacturers are:

- .1 Nexans;
- .2 Prysmian Cables (Pirelli);
- .3 General Cable;
- .4 Aetna Cables;
- .5 Kerite Company.

3 EXECUTION

3.01 PROJECT CONDITIONS

- .1 If identified in documents, verify that field measurements and conditions are as identified.
- .2 Cable routing on drawings is schematic and approximate. Route cable as required to meet project conditions. Determine exact routing and lengths on site.
- .3 Confirm fire protection ratings of construction to ensure that rooms and paths of conductors are fire rated in accordance with local governing codes requirements. Include fire rated conductors as required to meet local governing codes requirements.

3.02 CO-ORDINATION

- .1 Co-ordinate work with work provided under other electrical work and work of other trades.
- .2 Determine required separation between cable and other work.
- .3 Determine cable routing to avoid interference with other work.
- .4 Submit any alternative cable routing to Consultant for review prior to proceeding with work.

3.03 INSTALLATION OF CONDUCTORS

- .1 Provide required conductors. Ensure fire rated conductors are provided for applications as required by local governing codes, standards and local governing authorities.
- .2 In applications where multiple conductors in conduit are being run, provide a trapeze configuration of metal C-channels and threaded rod hangers to support cable/conduit from ceiling slab. Wall mounted cable/conduit brackets and ring type conduit hangers may also be permitted in applications approved by Consultant. Provide required cable support system accessories which are not specified herein or shown on drawings but are required for proper installation.
- .3 Conductors, unless otherwise noted, to be as follows:
 - .1 underground inside or outside building, outdoor and for non-climate controlled areas - "RWU90";
 - .2 for connections to electric heating coils in supply air ductwork systems, and for connections to other electric heating equipment where use of 90 degrees C. rated conductors are recommended by heating equipment manufacturer - "RW90";

- .3 for conductors requiring fire rating by current regulations and local codes including feeders for emergency systems, fire fighter's elevators, fire alarm systems, other life safety systems and for applicable signal and control circuits of these systems - type "MI" CSA approved, ULC listed and labelled, 2 hour fire rated, copper sheathed mineral insulated copper conductors;
- .4 climate controlled areas branch circuit wiring in accessible ceiling spaces and within stud wall construction consisting of drops down to luminaries and drops down stud walls to devices and in furniture systems - "AC90" flexible armoured cable ("BX") (maximum 3m (10') from ceiling junction box to luminaire or maximum 6m (20') run permitted to supply wiring devices in drywall partitions);
- .5 for climate controlled areas wiring except as noted above or specified elsewhere in Specification or as noted on drawings - "T90 Nylon" or "RW90".
- .4 Where flexible armoured cable are permitted to be installed, provide hanger support every 3-4 feet to promote straight runs, and label every 3-4 feet for conductor identification..
- .5 Install compression connectors with proper dies and compression tool as per connector manufacturer's instructions. Install cold shrink tubing and associated materials as per manufacturer's instructions.
- .6 Low voltage conductors to typically be No. 18 AWG "TEW" except for use in fire alarm system applications, unless otherwise noted. Provide specified fire alarm cables for fire alarm system applications or security system applications as approved by Code and local governing authorities. Conductors not installed in conduit or raceways to be fire insulated rated in accordance with latest governing Code Flame Spread requirements.
- .7 Generally, conductor sizes are indicated on drawings. Such sizes are minimum requirements and must be increased, where required, to suit length of run and voltage drop in accordance with applicable codes, and to meet following Owner's standards:
 - .1 Size branch circuit wiring for a 2% maximum voltage drop to farthest outlet based on circuit rating.
 - .2 Home runs to lighting and receptacle panels which exceed 75 ft. (25m) shall be minimum No. 10 AWG.
 - .3 For -80°C Freezer wiring:
 - .1 if longer than 50ft. (15m), use minimum No.10 AWG;
 - .2 if longer than 100ft. (30m), use minimum No.8 AWG;
 - .3 if longer than 150ft. (45m), not recommended.
- .8 Do not use conductors smaller than No. 12 AWG in systems over 30 volts, unless otherwise noted. Do not use conductors smaller than No. 6 AWG for exterior luminaire wiring unless otherwise noted.
- .9 Colour code conductors throughout to identify phases, neutrals and ground by means of self-laminating coloured tape, coloured conductor insulation, or properly secured coloured plastic discs. Colours, unless otherwise noted, to be as follows:

- .1 Phase A - red;
 - .2 Phase B - black;
 - .3 Phase C - blue;
 - .4 Ground - green;
 - .5 Neutral - white;
 - .6 Control - orange.
-
- .10 When pulling wires into conduit use lubricant and ensure that wires are kept straight and are not twisted or abraided.
 - .11 Control conductors, in addition, to be numbered with Brady Ltd. or Electrovert Ltd. Z type markers.
 - .12 Colour code conductors for communications systems in accordance with system component manufacturer's recommendations.
 - .13 Neatly secure exposed wire in apparatus enclosures with approved supports or ties.
 - .14 Install low voltage conductors in conduits, unless otherwise noted within Documents.
 - .15 Termination lugs for feeder cables shall be compression type.
 - .16 When a project is to include new wiring, wiring upgrades or rewiring, all the existing wiring that is no longer in service shall be removed as part of the project.

3.04 INSTALLATION OF FIRE RATED CONDUCTORS

- .1 Submit with shop drawings, copy of manufacturer's detailed installation manual and testing procedures. Provide minimum 2 hour fire rated type "MI" CSA approved, ULC listed and labelled, mineral insulated copper conductors for following:
 - .1 feeders to emergency lighting panel boards;
 - .2 feeders to fire alarm control panels and transponders;
 - .3 feeders as required by Code requirements;
 - .4 applicable local governing code required applications for control and signalling conductor circuits of and between life safety equipment and systems;
 - .5 feeders and conductors as noted on drawings.
- .2 Provide fire rated type "MI" conductors for specific feeders as required and as noted. Install type "MI" copper sheathed, mineral insulated conductors for applications noted above and as shown on drawings in strict accordance with the manufacturer's instructions and recommendations. Refer to latest issue of Pyrotex MI cable Commercial Wiring Installation Manual. Installation must be in a neat and professional manner as per manufacturer's approval. Make arrangements for manufacturer's technician to provide onsite services as specified.

- .3 Provide Unistrut C-channels, clips, wall brackets, etc., as required and as recommended by cable manufacturer to suit the on-site installation conditions. Provide system of Unistrut hangers and rods spaced at minimum 1.2 m (4') but which must be confirmed with cable manufacturer, for running of cables. Where clips and other hardware are in contact with cables, insulate cables/hardware with suitable tape as per cable manufacturer's recommendations for applications of dissimilar metals.
- .4 Make terminations of "MI" conductors with manufacturer's approved components and "Pyropak" or "Quick Term" connectors in accordance with the manufacturer's recommendations. Obtain proper tools for cable terminals from the cable manufacturer. Terminations must be completed immediately once started to avoid moisture ingress from the surrounding air. Connections to ferrous cabinets for single conductor cables shall incorporate brass plates sized as required and as per cable manufacturer's requirements. Brass plates shall be complete with required drilled and tapped holes. For 99°C applications, cable lugs shall be temperature rated as such.
- .5 Provide factory splices of "MI" cables where noted on drawings as coordinated with Consultant and by means as per manufacturer's instructions. Splices to include overall weatherproof heat-shrinkable tubing. Clearly identify splice with proper identification labelling/markers and locate on as-builts. Comply with manufacturer's instructions.
- .6 When pulling cable, apply pulling tension to the conductor not in the sheath of the cable. Limit cable pulling tension to as recommended by cable manufacturer.
- .7 Terminate cable in the equipment with termination kits as per cable manufacturer's instructions.
- .8 Installation of cable splices and terminations to be witnessed by manufacturer's authorized technician. Perform splicing and terminations in accordance with cable manufacturer's instructions. Ensure that space for splices is sufficient to properly accommodate bundled cables and splice box.
- .9 Ground cabling as per cable manufacturer's instructions and as per local governing electrical code requirements.
- .10 Take necessary precautions when handling cable on reel to ensure that no damage will result in the uncoiling process.
- .11 Where cables penetrate fire rated construction, provide ULC listed and labelled, fire stopping and smoke seal materials or fittings to protect integrity of fire rated construction. Install work in compliance with ULC standards and where required by local governing codes, provide tray type suitable for plenum environments.
- .12 Type "MI" cables shall be identified with colour codes (refer to colour codes for junction box cover plates in section 26 05 00) every 3m (10ft.) of cable run.
- .13 Test MI cables after installation, in strict accordance with cable manufacturer's instructions. Megger terminations to check that insulation resistance is acceptable to cable manufacturer. Prior to completing each termination, test insulation resistance and follow cable manufacturer's drying procedures until resistance reaches cable manufacturer's listed acceptable level.

- .14 Provide for cable manufacturer's authorized representative to review the installation, termination, splicing and testing of installed cables. Prepare report consisting of test sheets with results of cables tested and a certificate of verification signed by testing engineer/technician. Report to include copy of cable manufacturer's signed inspection letter documenting that work was performed to satisfaction of manufacturer. Submit minimum 3 hard copies and electronic copy to Consultant.

3.05 INSTALLATION OF TECK CABLES

- .1 Provide cables as required for specific applications. Handle, install, and terminate in accordance with manufacturer's recommendations and instructions and as herein specified.
- .2 When pulling cable, apply pulling tension to conductor not in sheath of cable. Limit cable pulling tension to as recommended by cable manufacturer.
- .3 Terminate cable in equipment with lugs and termination kits as per cable manufacturer's instructions.
- .4 Installation of terminations to be made by personnel skilled in this type of work.
- .5 Ground shielding as per cable manufacturer's instructions.
- .6 Take necessary precautions when handling cable on reel to ensure that no damage will result in uncoiling process.
- .7 No splices are allowed.

3.06 CABLE SPLICE KITS

- .1 No splices shall be installed on any low voltage power feeders.

END OF SECTION

1 GENERAL

1.01 SUBMITTALS

- .1 Submit shop drawings for products and accessories.

2 PRODUCTS

2.01 BASIC MATERIALS

- .1 Ground Conductors: Solid copper, insulated and bare to suit application and code requirements; and bond conductors.
- .2 Ground Busbar: Solid copper busbar, predrilled for two-hole lug connections, of size of 50 mm x 9 mm x 900 mm (2" x 3/8" x 36"), for wall and backboard mounting using standoff insulators.
- .3 Ground Connections:
 - .1 Below Grade: Cadweld as supplied by Erico Products or approved equal, exothermic-welded type connectors.
 - .2 Above Grade or in Manholes: Compression type connectors; Exothermic connections permitted above grade if approved by Consultant.
 - .3 When making ground and bonding connections, apply a corrosion inhibitor to contact surfaces. Use corrosion inhibitor appropriate for protecting a connection between metals used.
- .4 Miscellaneous ancillary components to complete grounding and bonding work to requirements of local governing electrical authority and codes.

2.02 TELECOMMUNICATIONS

- .1 Telecommunications Equipment Rack And Cabinet Ground Bars: solid copper ground bars designed for mounting on framework of open or cabinet-enclosed equipment racks with minimum dimensions of 6 mm (1/4") thick by 20 mm (3/4") wide; At any equipment mounting location (e.g., backboards and hinged cover enclosures) where rack-type ground bars cannot be mounted, provide screw lug-type terminal blocks. Where bolting to painted surfaces, use paint piercing type washers.
- .2 LAN Room Ground Bus: 50 mm x 9 mm x 300 mm (2" x 3/8" x 12") copper ground bus with eight (8) drilled taped holes; mounted on walls with standoff insulators.
- .3 Ground Conductor for Grounding Grid and Associated Connections: Number 3/0 AWG bare, 7-strand medium hard-drawn copper unless indicated otherwise.
- .4 Ground Braid: constructed from flat 98% conductivity tinned copper grounding braid.

3 EXECUTION

3.01 GENERAL GROUNDING AND BONDING REQUIREMENTS

- .1 Provide required grounding and bonding work in accordance with drawings, local governing electrical authority, governing authorities having jurisdiction and local governing electrical inspection authority. Provide local governing electrical utility's grounding requirements for stations, vaults and electrical rooms, as applicable. Confirm requirements with local governing electrical utility.
- .2 Provide 50 mm x 9 mm x 900 mm (2" x 3/8" x 36") electrical grade copper ground bus on perimeter wall of electrical rooms, 300 mm (12") above finished floor level. Secure ground bus on 20 mm (3/4") standoff insulators. Connect electrical rooms ground grid with ground bus with minimum 3/0 copper ground conductor in conduit. Connect each electrical room perimeter ground electrode system back to main electrical room ground electrode with minimum No. 3/0 copper conductors.
- .3 Ground and bond other equipment such as transformers, switchboards, panelboards, and similar metal work to perimeter ground bus. Provide minimum No. 3/0 insulated ground wire from ground bus in electrical rooms to switchboards, transformers, structure, floor, etc.
- .4 Extend conductors to existing grounding conductors of building.
- .5 When buses are in place, bolts have been tightened, and lugs have been installed, coat entire installation with two (2) 100% covering coats of suitable shellac to prevent bus from oxidizing.
- .6 Throughout complex, solidly ground systems and make required grounding connections to electrical devices and apparatus. Ground conductors to be insulated copper wire connected with approved fittings in accordance with local governing electrical code.
- .7 Connect grounding conductors to motors 10 hp and above or circuits 20A or above, with a solderless terminal and a bolt tapped to motor frame or equipment housing. Connect to smaller motors or equipment by fastening terminal to a connection box. Connect junction boxes to equipment grounding system with grounding clips mounted directly on box or with machine screws. Completely remove paint, dirt, or other surface coverings at grounding conductor connection points so good metal-to-metal contact is made.
- .8 Provide service conductors exceeding 400 amperes with minimum No. 3/0 AWG grounding conductors, unless otherwise noted.
- .9 Ground and bond various telecommunications, audio visual systems, security, life safety and control systems in accordance with respective system manufacturers recommendations and in accordance with local governing electrical code requirements.
- .10 Provide minimum no. 3/0 AWG insulated copper ground conductors and LAN Room copper ground bus mounted on walls with standoff insulators in each LAN room. Connect ground bus to computer equipment racks and to building ground system.
- .11 Ground conductors not sized on drawings are to be sized in accordance with local governing electrical authority requirements. Ground conductor size is to be no smaller than requirements specified herein this article or on drawings.

3.02 ADDITIONAL TELECOMMUNICATIONS GROUNDING

- .1 Comply with TIA/EIA-607 grounding and bonding requirements.
- .2 Provide wire and hardware required to properly ground, bond, and connect communications raceway, cable tray, metallic cable shields, and equipment to a ground source.
- .3 Ground bonding jumpers to be continuous with no splices. Use shortest length of bonding jumper possible.
- .4 Provide ground paths which are permanent and continuous with a resistance of 1 ohm or less from raceway, cable tray, and equipment connections to building grounding electrode. Resistance across individual bonding connections to be 10 milliohms or less.
- .5 Bonding Jumpers:
 - .1 Use insulated ground wire of size and type if identified on Drawings if not identified, comply with local governing code, but which is to be a minimum of No. 6-AWG insulated copper wire.
 - .2 Assemble bonding jumpers using insulated ground wire terminated with compression connectors.
 - .3 Use compression connectors of proper size for conductors specified. Use connector manufacturer's compression tool.
- .6 Bonding Jumper Fasteners:
 - .1 Conduit: Fasten bonding jumpers using screw lugs on grounding bushings or conduit strut clamps, or clamp pads on push-type conduit fasteners. When screw lug connection to a conduit strut clamp is not possible, fasten plain end of a bonding jumper wire by slipping this plain end under conduit strut clamp pad; tighten clamp screw firmly. Where appropriate, use zinc-plated external tooth lockwashers.
 - .2 Wireway and Cable Tray: Fasten bonding jumpers using zinc-plated bolts, external tooth lockwashers, and nuts. Install protective cover; e.g., zinc-plated acorn nuts, on any bolts extending into wireway or cable tray to prevent cable damage.
 - .3 Ground Plates and Busbars: Fasten bonding jumpers using two-hole compression lugs. Use tin-plated copper or copper alloy bolts, external tooth lockwashers, and nuts.
 - .4 Unistrut and Raised Floor Stringers: Fasten bonding jumpers using zinc-plated, self-drill screws and external tooth lockwashers.
- .7 Building Ground Busbars:
 - .1 Provide busbar hardware at each communications room and connect to pigtail extensions of building grounding ring.
 - .2 Verify that ground ring pigtail is same type and size conductor used for main building grounding ring.

- .8 Telecommunications Ground Busbars:
 - .1 Provide communications room telecommunications ground busbar hardware at cable tray height.
 - .2 Connect busbar to building ground busbar located in same room using two-hole compression lugs and a grounding jumper of same size as pigtail extension of main building grounding ring (usually 3/0 AWG).
- .9 Ground metallic conduits, wireways, and other metallic equipment located away from equipment racks or cabinets to cable tray pan or telecommunications ground busbar, whichever is closer, using insulated No. 6-AWG ground wire bonding jumpers.
- .10 Ground metallic conduit at each end using No. 6-AWG bonding jumpers.
- .11 Comply with cable tray manufacturer's grounding and bonding recommendations. Bond metallic structures of wireway to provide 100% electrical continuity throughout wireway system.

END OF SECTION

1 GENERAL

1.01 SUBMITTALS

- .1 Submit shop drawings for products specified in this Section.

2 PRODUCTS

2.01 BASKET CABLE TRAY

- .1 CSA approved and labelled, basket type cable tray system complete with factory made couplers, fittings, tee sections, elbows, universal dropouts, etc., and required supporting and installation accessories. Features include but are not limited to following:
 - .1 minimum 300 mm x 100 mm (12" x 4") unless otherwise noted on drawings;
 - .2 welded wire construction of minimum 5 mm (0.197") diameter carbon steel wires and hardware, conforming to requirements of ASTM A510 Grade 1008 with black powder coated finish paint to ASTM D 3451;
 - .3 continuous, rigid, welded steel wire mesh cable tray system;
 - .4 top wire safety edge;
 - .5 wire mesh welded at intersections;
 - .6 mesh sections having minimum one (1) bottom longitudinal wire along entire length;
 - .7 warning signs;
 - .8 accessories included as required.
- .2 Prior to start of work, prepare and submit detailed installation drawings, including plans, elevations and sections of proposed tray and routing. Coordinate such drawings with coordination drawings of trades. Include for design calculations to determine load limitations.
- .3 Tray to not have sharp edges that may damage cables during running of cables. Final finish to be smooth with no burrs that may damage cables.
- .4 Use manufacturer's trained and certified installers to perform work. Use tools as recommended by and supplied by tray manufacturer. Utilize manufacturer's supplied cutter for cutting tray. Submit with shop drawings, copies of installing technicians' certificates of training on respective tray systems.
- .5 Provide support of a trapeze configuration containing horizontal hanger brackets and vertical threaded rods on each side. Secure rods to brackets as per system manufacturer's instructions. Space supports at maximum 1.5 m (5'), to provide support of loads up to 53 kg/m (36 lbs per foot).

- .6 Provide support of a center hanging configuration containing horizontal hanger brackets and vertical threaded PVC insulated rods in middle. Secure rods to brackets as per system manufacturer's instructions. Space supports at maximum 1.5 m (5'), to provide support of loads up to 53 kg/m (36 lbs per foot).
- .7 Where cable tray penetrates fire rated construction, provide ULC listed and labelled, fire stopping and smoke seal materials or fittings to protect integrity of fire rated construction. Install work in compliance with ULC standards and where required by local governing codes, provide suitable for plenum environments.
- .8 Provide tray complete with grounding/bonding provisions, fittings, tee sections, elbows, universal dropouts, expansion fittings, etc., and required supporting and installation accessories. Provide dividers to separate various system cabling to a degree confirmed by Consultant, but typically two (2) dividers in a 300 mm (12") wide tray. Provide conduit fittings where conduits enter tray and provide dropouts at ends where cables exit/enter. Supply cable installation rollers for pulling cables safely into tray. System accessories to be supplied by system manufacturer and be as recommended by system manufacturer for specific applications.
- .9 Acceptable manufacturers are:
 - .1 Legrand-Cablofil;
 - .2 Cooper "Flextray";
 - .3 Eaton B-Line;
 - .4 Canadian Electrical Raceways;
 - .5 Hubbell;
 - .6 WBT.

2.02 LADDER CABLE TRAY

- .1 CSA approved and labelled, ladder type cable tray as follows:
 - .1 in compliance with CSA C22.2 No. 126.1 and NEMA VE1;
 - .2 sized generally 300 mm W x 100 mm D (12" x 4") unless otherwise noted on drawings;
 - .3 side rails and rungs constructed of pre-galvanized steel conforming to requirements of ASTM A653 with G90 coating thickness;
 - .4 side rails reinforced with flanges;
 - .5 maximum 150 mm (6") rung spacing and supplied in 3 m (10') lengths;
 - .6 rated for minimum CSA load D unless otherwise noted on drawings; cable tray to meet required NEMA/CSA load ratings with safety factor of 1.5 and also be able to support a 90 kg (200 lb) concentrated load at midspan over and above cable load;
 - .7 refer to drawings for approximate tray routings and lengths.
- .2 Accessories:
 - .1 Factory made conduit connectors, couplers, fittings, tee sections, elbows, universal dropouts.

- .2 Seismic restraints to local governing building code requirements to prevent horizontal movement.
- .3 Grounding and bonding jumpers and hardware to maintain electrical continuity.
- .4 Required supporting and installation accessories.
- .3 Include for a trapeze configuration of threaded rod supports secured to ceiling slab and extending down to secure to steel C-channel support, creating a cradle for support of system. Cable tray to be connected continuously with no breaks.
- .4 Prior to start of work, prepare and submit detailed installation drawings, including plans, elevations and sections of proposed tray and routing. Coordinate such drawings with coordination drawings of trades. Include for design calculations to determine load limitations.
- .5 Clean final finish of burrs and other material or imperfections prior to installation of cabling, to satisfaction of Consultant. Final finish to be smooth with no burrs that may damage cables.
- .6 Provide tray complete with tray manufacturer's grounding/bonding fittings and hardware.
- .7 Provide conduit fittings where conduits enter tray and provide dropouts at ends where cables exit/enter. Supply cable installation rollers for pulling cables safely into tray. Provide rollers or other hardware to maintain cable-bending radii within cable manufacturer's recommended standards to suit type of cable. System accessories to be supplied by system manufacturer and be as recommended by system manufacturer for specific applications.
- .8 Factory fabricate changes in direction, tees, 90° bends, universal dropouts, etc.
- .9 Where cable tray penetrates fire rated construction, provide ULC listed and labelled, fire stopping and smoke seal materials or fittings to protect integrity of fire rated construction. Install work in compliance with ULC standards and where required by local governing codes, provide tray type suitable for plenum environments.
- .10 Acceptable manufacturers are:
 - .1 Thomas & Betts;
 - .2 Legrand;
 - .3 Eaton B-Line;
 - .4 Canadian Electrical Raceways.

2.03 CABLE DUCT

- .1 CSA approved and labelled, 250 mm (10") wide, 100 mm (4") deep, unless otherwise noted on drawings, constructed from No. 16 gauge galvanized steel, barriered 3-compartment solid bottom custom cable duct wireway supplied in 3 m (10') lengths with hinged covers supplied in 1.5 m (5') long sections and complete with required dividers, conduit knockouts, elbows, fittings, end closures, grommet ends, couplings, etc., and required mounting and connection hardware.
- .2 Prior to start of work, prepare and submit detailed installation drawings, including plans, elevations and sections of proposed routing. Coordinate such drawings with coordination drawings of trades.

- .3 Lengths of ducts, number of barriers and cover types may vary depending on site installation requirements. For flush or surface mounted applications, provide removable screw-on or hinged covers of lengths to avoid supports and to accommodate restricted spaces are required to suit and are to be reviewed and coordinated with Consultant. Ducts within walls do not require removable covers.
- .4 For surface wall mounting applications, cable duct to be complete with drilled holes for mounting and wall brackets.
- .5 For ceiling suspended applications, provide support of a trapeze configuration containing horizontal hanger brackets and vertical threaded rods on each side of duct. Secure rods to brackets and ceiling slab as per system manufacturer's instructions.
- .6 Entire duct system to be provided with powder coat finish of colour confirmed with Consultant.
- .7 Submit with shop drawings, copy of CSA certificate of approval for specified ducts.
- .8 Acceptable manufacturers are:
 - .1 Legrand -Wiremold;
 - .2 Thomas & Betts;
 - .3 Canadian Electrical Raceways.

2.04 SURFACE RACEWAYS

- .1 CSA certified, ULC listed and labelled, surface mounted, painted non-metallic service raceways, complete with clips, couplings, brackets, fittings, elbows, boxes, tees, mounting hardware, etc., for a complete raceway system.
- .2 Generally, type of raceways is noted on drawings, but in absence of direction, in areas where multiple services are required, provide multi-compartment raceways to suit application. Where only single service is required, provide single type raceways. Provide stainless steel type raceways in laboratories, testing/treatment rooms and similar type rooms. Confirm exact requirements with Consultant.
- .3 Coordinate and measure exact dimensions for lengths, to meet site installation. Where horizontal sections meet vertical sections, provide manufacturer's proper connecting fitting such that there are no openings or exposed conductors. Ensure that bending radii requirements of various cabling standards are met.
- .4 Coordinate requirements for data/voice jacks and wiring with telecommunications network cabling specialist trade. Size raceways for computer network structured cabling in compliance with EIA/TIA Standards for required Category of cabling as per section entitled Structured Cabling. Increase raceway sizing to suit.
- .5 Acceptable manufacturers are:
 - .1 Legrand -Wiremold;
 - .2 Thomas & Betts;
 - .3 Hubbell;
 - .4 Panduit.

2.05 LOW PROFILE FLOOR SURFACE RACEWAYS

- .1 CSA certified, ULC listed and labelled, 2-compartment, low profile floor surface mounted, painted non-metallic service raceways, complete with clips, couplings, brackets, fittings, elbows, end, boxes, tees, ramps, mounting hardware, wiring for power, cover, etc., for a complete raceway system.
- .2 Power/Data Separation: provide a permanent and listed barrier between the power conductors and communications cabling in the wireway channel.
- .3 Data Capacity: 40% fill rules apply.
- .4 Entrance Fittings are quick connectors that power the entire raceway by converting the building mains power to the raceway power system. The In-Wall Entrance Fitting starts at the wall and is used when power/data cabling is running INSIDE the wall. The Surface-Mounted Entrance Fitting starts at the wall and is used when power/data cabling is running OUTSIDE the wall.
- .5 Base Trim covers the hole in the wall and is placed at the entrance of the raceway.
- .6 Provide transition ramps, sit adjacent to the raceway, as an ADA compliant transition from the raceway to the surrounding flooring.
- .7 Coordinate and measure exact dimensions for lengths, to meet site installation. Where horizontal sections meet vertical sections, provide manufacturer's proper connecting fitting such that there are no openings or exposed conductors. Ensure that bending radii requirements of various cabling standards are met.
- .8 Coordinate requirements for data/voice jacks and wiring with telecommunications network cabling specialist trade. Size raceways for computer network structured cabling in compliance with EIA/TIA Standards for required Category of cabling as per section entitled Structured Cabling. Increase raceway sizing to suit.
- .9 Acceptable manufacturers are:
 - .1 Legrand – Connectrac / Wiremold;
 - .2 Thomas & Betts;
 - .3 Hubbell;
 - .4 Panduit.

3 EXECUTION

3.01 INSTALLATION OF CABLE TRAY

- .1 Provide sample of tray and detailed drawing layout of work prior to start of work, accurately dimensioned and showing required routing, penetrations, connections, bends, supports, etc.
- .2 Obtain required training from manufacturer's representative on any special installation procedures. Install tray in accordance with manufacturer's instructions to suit specific installation requirements. Use manufacturer's recommended tools for cutting and installing tray.

- .3 Drawings are diagrammatic and do not identify required changes in elevations and architectural features. Site measure exact routing and lengths. Provide detailed drawing layout of work prior to start of work, accurately dimensioned and showing required penetrations, connections, bends, etc.
- .4 Install and hang cable tray at maximum 1.5 m (5') centres and in accordance with manufacturer's published literature employing horizontal bracket supported to ceiling slab by vertical threaded rod hangers. Do not secure assembly from ductwork, suspended ceiling structures, lighting, etc. Secure rod hangers directly to ceiling slab. Locate supports as not to interfere with removal or opening of covers. Typically locate spans at intervals $\frac{1}{4}$ span from supports, as recommended by tray manufacturer. Refer to drawing details and/or manufacturer's instructions. Include for provision of required seismic restraints as to comply with local governing building code requirements.
- .5 Provide proper fittings in cable tray at points of conduit entry. Terminate conduits at or in tray with proper grommetted and bushed terminations.
- .6 Equip tray with necessary wall flanges, dropouts, enclosures, reducers, fittings, and similar accessories required, maintaining effective free cross-sectional area of tray clear of obstructions that might damage conductor insulation during installation.
- .7 Properly secure, adequately support and neatly harness conductors in tray. Seal cable tray penetrations of building fire barriers by means of ULC listed and labelled fire stopping and smoke sealing material.
- .8 Provide continuous paths along entire lengths of cable tray to maintain proper ground continuity. Utilize system manufacturer's proper grounding and bonding fittings and hardware. Ground and bond system as per local governing electrical code requirements.
- .9 File smooth cuts to tray and re-touch with galvanizing compound.
- .10 Install expansion connectors where cable tray crosses building expansion joints.
- .11 After installation is complete, install warning signs on tray in visible locations.
- .12 Inspect tray for rough finishing burrs, sharp edges, and mechanical deficiencies prior to installing of cabling. Eliminate these deficiencies to satisfaction of Consultant, prior to installing cables.

3.02 INSTALLATION OF CABLE DUCT

- .1 Provide sample of duct and detailed drawing layout of work prior to start of work, accurately dimensioned and showing required routing, penetrations, connections, bends, supports, etc.
- .2 Obtain required training from manufacturer's representative on any special installation procedures. Install tray in accordance with manufacturer's instructions to suit specific installation requirements. Use manufacturer's recommended tools for cutting and installing duct.
- .3 Drawings are diagrammatic and do not identify required changes in elevations and architectural features. Site measure exact routing and lengths. Provide detailed drawing layout of work prior to start of work, accurately dimensioned and showing required penetrations, connections, bends, etc.

- .4 Provide cable duct with required covers. Provide required components and required mounting and connection accessories.
- .5 Secure surface wall mounted duct in place with mounting hardware recommended by duct manufacturer to suit specific installation.
- .6 Install and hang cable duct at maximum 1.5 m (5') centres and in accordance with manufacturer's published literature employing horizontal bracket supported to ceiling slab by vertical threaded rod hangers on each end. Do not secure assembly from ductwork, suspended ceiling structures, lighting, etc. Secure rod hangers directly to ceiling slab. Locate supports as not to interfere with removal or opening of covers. Refer to drawing details and/or manufacturer's instructions.
- .7 Provide proper fittings in cable duct at point of conduit entry. Terminate conduits at or in duct with proper grommetted and bushed terminations.
- .8 Equip duct with necessary wall flanges, dropouts, enclosures, reducers, fittings, and similar accessories required, maintaining effective free cross-sectional area of duct clear of obstructions that might damage conductor insulation during installation.
- .9 Properly secure, adequately support and neatly harness conductors in duct. Seal cable duct penetrations of building fire barriers by means of ULC listed and labelled fire stopping and smoke sealing material.
- .10 Provide continuous paths along entire lengths of cable duct to maintain proper ground continuity. Utilize system manufacturer's proper grounding fittings and hardware.
- .11 Install expansion connectors where cable duct crosses building expansion joints.
- .12 After installation is complete, install warning signs on duct in visible locations.
- .13 Inspect duct for rough finishing burrs, sharp edges, and mechanical deficiencies prior to installing of cabling. Eliminate these deficiencies to satisfaction of Consultant, prior to installing cables.

3.03 INSTALLATION OF SURFACE RACEWAYS

- .1 Provide surface mounted raceway assemblies complete with specified and required accessories necessary for a complete electrical raceway system. Site measure for proper lengths. Confirm finishes with Consultant prior to ordering.
- .2 Obtain required training from manufacturer's representative on any special installation procedures. Install raceways in accordance with manufacturer's instructions to suit specific installation requirements. Use manufacturer's recommended tools for cutting and installing raceways.
- .3 Assemble and secure raceways, boxes and other components to surfaces in accordance with manufacturer's instructions and requirements. Connect complete. Where possible butt raceway ends to adjacent walls, cabinets, counters, etc. Where raceway is to be attached to equipment or sections of millwork, install raceway for full length of equipment/millwork, unless otherwise noted. Mount-faceplates flush to raceway with no gaps. Keep number of elbows, offsets and connectors to a minimum.
- .4 Do not exceed wire fill requirements given in manufacturer's instructions.

- .5 Provide barriers for systems with different voltages in raceway.
- .6 Test prewired raceways after installation work is complete.
- .7 Provide wiring devices of types and standards as specified in wiring devices section.
- .8 Coordinate requirements with structured cabling system vendor to ensure that raceways are suitable for and comply with standard for telecommunication jacks and cabling.
Ensure that device mounting brackets are co-ordinated to suit final modular jack being installed.

END OF SECTION

1 GENERAL

1.01 SUBMITTALS

- .1 Submit power system studies as part of shop drawing submission, including follows:
 - .1 electrical distribution system short circuit calculations and protective device coordination study;
 - .2 arc flash analysis report.
- .2 Submit electrical distribution system short circuit calculations and protective device coordination study reports prior to or with proposed shop drawings of all relevant electrical distribution equipment. Allow in shop drawing process, sufficient time for Consultant to review and make comments and for Contractor and equipment vendors to incorporate Consultant comments, necessary revisions and results of reports into equipment shop drawings. Do not order equipment until shop drawings are acceptable to Consultant. Time for this shop drawing review process will be at Consultant's discretion, but typically allow for 15 working days for initial review submission with additional 10 working days added to accommodate each resubmission.
- .3 Submit arc flash study with calculations for use in determining required electric shock and arc flash protection.
- .4 Submit after completion of factory testing, copies of completed product testing reports.
- .5 Submit after installation and testing, copies of:
 - .1 completed testing reports with completed test results sheets;
 - .2 certificate of approvals from local governing authorities, manufacturers' of systems and equipment and testing companies.
- .6 Verify form of submittals (submission procedures, number of hard copies and requirements for electronic copies) with Consultant at project start-up. For pricing assume minimum 3 hard coloured copies bound, electronic pdf copy, and electronic .OTI file (for the electrical model for all reports and studies).

2 PRODUCTS

2.01 GENERAL SCOPE OF WORK

- .1 Short-Circuit Studies
 - .1 Short circuit studies shall be conducted to identify the withstand and interrupting capability of electrical equipment; and determine the bolted fault currents (Ibf) required for arc flash calculations.
 - .2 Short circuit calculations shall be calculated at all points in the electrical system down to each 120/208V branch panel, regardless of the kVA rating of the upstream transformer.

- .3 All three-phase induction motors greater than 40HP shall be modeled and contribute to the available short circuit current in the model. If the motor to be modeled is connected to a VFD, it shall be modeled as such but will still allow full fault contribution as if it were connected directly to the line voltage. This is to assume the worst case should the VFD be in bypass mode.
- .4 Inverters rated 10kW or above and connected to DC systems shall be modeled. Their short circuit let-through values shall be modeled as per manufacturer specifications.
- .2 Coordination Studies
 - .1 Coordination studies shall be undertaken for new / replaced / modified electrical distribution equipment.
 - .2 Coordination studies shall be undertaken for each coordination path down to the main isolation point for each branch circuit panel.
 - .3 The Time Current Curves (TCCs) shall show coordination between each level of protection for a bolted fault downstream of the main isolation point for the worst-case branch circuit panel.
- .3 Arc-Flash Hazard Analysis
 - .1 Arc Flash studies shall be performed for all new / replaced / modified electrical equipment where there may be a potential for exposed live electrical work (switchgears, panelboards, transformers, motor disconnects, VFDs, etc.)
 - .2 Where the nominal voltage is less than 240V and the calculated I_{bf} is less than or equal to 2000A, the label shall show an incident energy of 1.2 cal/cm². Otherwise, the calculation shall be performed in accordance with IEEE 1584-2018.
 - .3 The following considerations shall be considered for each panelboard or switchgear. Using global defaults in the model is not acceptable:
 - .1 Electrode configurations (VCB, VCBB, HCB, VOA, HOA) for each applicable cell or instance. For example, an MCC enclosure may contain both VCB and VCBB instances and the worst case shall be calculated.
 - .2 Number of separately barriered sections (such as the main breaker, withdrawable breakers, etc.).
 - .3 Enclosure dimensions.
 - .4 Conductor distance to worker.
 - .4 All new electrical distribution equipment (including branch circuit panelboards) shall be provided with arc flash labels, based on short circuit, coordination, and arc flash study required as a project deliverable. The arc flash labels shall detail arc and shock hazards as per CSA-Z462. Final label configuration shall be approved by the university before installation.

- .5 If equipment is of metal-clad construction, at a minimum, each barriered section shall have its own arc flash label. (e.g., a double-ended switchboard with a main/tie/main configuration shall minimally have a label on each main breaker compartment, on the tie-breaker compartment, and each of the two load section compartments).
- .4 Include for but not be limited to following:
 - .1 preparing and submitting short circuit calculations, protective device coordination study and recommendations on required relays, sensors and CT's, and arc flash hazard analysis for sufficient withstand and interrupting capability of electrical equipment, proper system coordination, and determining required electric shock and arc flash protection;
 - .2 product manufacturers providing equipment inspection, testing, start-up, adjustments and verification;
 - .3 independent 3rd party testing of electrical distribution system equipment and associated products;
 - .4 independent 3rd party testing of systems and equipment as noted;
 - .5 electricians/trades people on site to handle equipment, make temporary connections, operate equipment and make repairs and adjustments and assist manufacturer's / testing organization's personnel during on-site inspection, testing, calibration, start-up, verification work and where supplementary commissioning;
 - .6 coordination of work with testing company and equipment/system manufacturer's authorized technician in performing adjustments and start-up procedures to equipment/systems;
 - .7 preparing testing reports and documentation for submission to Consultant.

3 EXECUTION

3.01 GENERAL REQUIREMENTS

- .1 The university has standardized ETAP® for carrying out all power system studies on campus. All Arc Flash and Short Circuit studies shall be performed using ETAP software (version 19 or higher and shall be backward compatible with version 19) and updated electrical models shall be made available to the university at project closeout.
- .2 The university shall provide the existing model for any required changes to perform the studies, for studies where the new equipment is downstream of the local utility.
- .3 A model shall be created, and electrical study shall be carried out for the addition / replacement / modification of any of the following pieces of equipment: Switchgears, Transformers, Transfer Switches, Panelboards, Generators, and/or Inverter / DC Systems.
- .4 All electrical system studies shall consider the following three scenarios:
 - .1 Utility maximum contribution

- .2 Utility minimum contribution
- .3 Building on Emergency supply
- .5 The electronic files for the electrical model for all reports and studies shall be provided to the university at the completion of the project as part of the closeout documents.

3.02 DISTRIBUTION SYSTEM COORDINATION STUDY AND SHORT CIRCUIT CALCULATIONS

- .1 Prepare coordination study and short circuit calculations (available fault currents) of system. Perform work to standards of applicable local governing authorities, local electrical inspection authority and CSA Standards.
- .2 Review and survey existing systems and/or obtain where available, coordination study of existing systems to use in determining best coordination for additional and revised equipment with existing systems. Where existing studies are not available, survey existing systems and prepare additional coordination studies as required to provide a full and proper coordination of entire existing, revised and additional systems.
- .3 Submit coordination study and short circuit calculations reports as part of shop drawing submission as specified in Part 1 article - Submittals. Ensure that results and Consultant's reviewed comments from these reports are incorporated into electrical distribution equipment shop drawings.
- .4 Protective system devices have been selected such that protection is adequate and good coordination is possible, however, since differences do exist between manufacturers, some changes in trip ratings or relay settings may be necessary and are to be carried out. Obtain local electrical utility information on their protective devices and include requirements as necessary.
- .5 Provide and carry out following:
 - .1 prepare a set of coordination curves on K.E. No. 336E Time Current Characteristic graph paper;
 - .2 this is to be accompanied by supporting symmetrical as well as asymmetrical fault current calculation data with tabulations to verify protection of various elements of systems under maximum and minimum fault conditions at various points in systems.
 - .3 Plot time-current characteristic curves for following:
 - .1 main and feeder protective devices at voltage levels used in distribution system;
 - .2 protective devices associated with largest motor in each MCC, refrigeration machine compressors and largest device in each distribution panel;
 - .3 motor generator protective devices, damage curves and current decrement curves.
- .6 Cooperate with and obtain from other manufacturers a list of equipment requiring protective devices to be used in distribution system and prepare coordination curves as soon as possible. Be responsible, along with other manufacturers' equipment connected to distribution system, to ensure that proper control and protective devices are selected such that they coordinate with protective devices.

- .7 It is responsibility of equipment manufacturers to examine plans and specifications to ensure that relays and protective devices being installed in distribution system provide satisfactory coordination.
- .8 Where automatic transfer switches are provided, submit coordination results available fault current values at locations of transfer switches, to transfer switch manufacturer to ensure that transfer switches provided are of suitable withstand current ratings.
- .9 Document testing, coordination study and arc flash analysis in a report signed by a Professional Engineer licensed in the Place of Work and authorized by testing company. Include for minimum 3 hard copies and electronic copy of report to be submitted to Consultant for review. Report to include test results with properly plotted curves, identified trouble areas of coordination, extensive comments regarding test results and recommendations on best course of remedial action.

3.03 GENERAL ELECTRICAL WORK TESTING

- .1 In addition to tests required by local governing authorities having jurisdiction, local codes and regulations, perform following:
 - .1 after luminaires, switches, receptacles, motors, signals, etc., are installed, whether same are installed as part of this Division or by other Divisions (telephone systems excepted), test work to ensure that there are no leaks, grounds or crosses;
 - .2 establish and ensure proper motor rotation - measure full load running currents and check overload elements - report to Consultant any discrepancies which are found; existing motors which have been worked on (disconnected and reconnected) must be checked with rotation meter to ensure proper rotation; be responsible for any damage caused by reverse rotation;
 - .3 demonstrate to Consultant that branch circuit voltage drop is within specified units;
 - .4 ensure that devices are commissioned and operable.
- .2 Document results into distribution system testing report. Report must state that testing was successful and Work complies with project documents, applicable CSA standards, and other applicable governing codes and requirements.

3.04 SYSTEMS INSPECTION, TESTING, START-UP AND VERIFICATION

- .1 When each system and each major piece of equipment installation is complete and ready for acceptance, include for system and equipment manufacturer or manufacturer's authorized representative to visit site to provide system inspection, testing, start-up, and verification. Perform following:
 - .1 check component connections and overall installation;
 - .2 adjust sound systems for high quality, distortion free performance, free from noise, cross-talk, hum or other interference;
 - .3 test and adjust system and ascertain that components are as specified and ensure that products operate as designed;
 - .4 provide start-up procedures for systems and equipment;

- .5 verify and certify system component operations;
- .6 prepare, document and evaluate test results;
- .7 authenticate test results with signature of authorized testing Engineer/Technician;
- .8 check and verify nameplates;
- .9 provide maintenance and operating instructions to Owner's personnel.
- .2 Perform work properly documented, and in accordance with manufacturer's instructions and recommendations.
- .3 Perform work under presence of Owner/Consultant/Commissioning Agent at times approved by Owner and reviewed with Consultant.
- .4 Where project includes LEED requirements, prepare, document, evaluate test results and provide additional documentation during inspection, start-up, testing and verification work that includes but is not limited to:
 - .1 submission of necessary LEED forms indicating percentage of recycled content in manufactured materials and devices to LEED consultant;
 - .2 testing and adjusting systems and ascertaining that components are as specified and adhere to LEED requirements;
 - .3 verification of systems and ensuring that operation and design of systems adhere to LEED requirements.
- .5 Provide these requirements after each phase (as applicable) to allow Owner option to use area of phase of work. These requirements are also to be provided prior to applying for Certificate of Substantial Performance of the Work of project.
- .6 Include for manufacturers authorized technicians of equipment/systems integrated to equipment/systems being tested to be onsite during full integration testing. Coordinate with each manufacturer.
- .7 When system inspection, testing, start-up and verification specified above is complete, obtain from supplier/manufacturer (or where specified, independent inspection company) a test report with test sheets, and covering verification letter signed by authorized testing technician, stating that system or equipment has been inspected and tested, performs as specified and is ready for acceptance. Include date and time of testing, testing technician's name and specification section number test fulfilled.
- .8 Bind documents under cover and submit minimum one hard copy and electronic copy to Consultant.

3.05 ELECTRICAL DISTRIBUTION SYSTEM TESTING AND VERIFICATION

- .1 Provide services consisting of on-site engineering inspection, testing and verification of electrical distribution equipment and other systems and equipment. Perform work to standards of applicable local governing authorities, local electrical inspection authority and CSA Standards.

- .2 Services to be performed by an approved independent testing company and be initially conducted prior to system/equipment being energized and further testing when energized, and include following items, where applicable:
 - .1 testing, cleaning when necessary, and calibrating relays and circuit breaker trip devices (calibration of protective devices to conform to requirements of approved coordination curves);
 - .2 function test of associated control devices;
 - .3 replacement of fuses destroyed during testing;
 - .4 an acceptance test in presence of Consultant;
 - .5 presence, for length of time required, of qualified and competent equipment manufacturer's service representative during start-up;
 - .6 carry out insulation resistance testing of outgoing feeders with respect to ground;
 - .7 inspection and testing of cables, bus duct, power panels, lighting panels, transformers, power receptacles and switches;
 - .8 inspection and testing of lighting control systems including central control systems, low voltage relays, sensors and dimming controls; ensure that devices perform in conformance with ASHRAE 90.1 requirements;
 - .9 verification and certification work of equipment and systems.
- .3 Perform services procedures properly documented, and in accordance with manufacturer's instructions and recommendations.
- .4 Forward to Consultant for review, minimum 3 hard copies and electronic file of engineering and testing report.
- .5 Where relays, breakers, etc., do not perform to Consultant reviewed coordination curves, revise as part of work.
- .6 Adjust and calibrate existing trip units, relays, breakers, etc., which do not perform to approved coordination curves. Where defective or incorrectly applied relays or breakers are found in existing distribution system, identify problem areas clearly on curves of test report and provide recommended course of remedial action. Where replacement of existing devices not identified in Documents to be replaced is necessary to provide coordination, submit estimate of costs to Consultant for review. Where directed by Owner, perform work at additional cost to Contract amount. Clearly show on coordination curves in report and clearly identify recommended remedial course of action.
- .7 Test high voltage cable installation before placing in regular service. Work includes phase verification, grounding verification, hi-pot test of insulation strength to IPCEA Specifications (Leakage Curves to be obtained), and time domain reflectometer tests to give records of cable impedance profiles to draw attention to cable damage. Reference cable manufacturers testing procedures and do not exceed maximum test voltage levels and durations.

- .8 Testing organization to report high voltage cable defects directly to Consultant as soon as such defects are discovered. Re-test affected cables after proper repair. Also, re-test cables in cases where cable damage after installation is suspected. On completion of satisfactory testing of installation, submit a report by testing organization stating that cables concerned have satisfactorily passed required tests and are suitable for service. Submit report for Consultant's review. Submit recorded test data (properly bound) with report, in each case.
- .9 Test main power transformers before placing in regular service. Work to include voltage ratio test, phase angle test, insulation resistance, oil sampling (liquid type transformer), start-up and other manufacturer's recommended tests.
- .10 Provide visual and mechanical inspection of ground system and verify that it is in compliance with issued documents and local governing electrical code requirements.
- .11 Additionally, perform testing of lighting control systems and devices to ensure conformance with ASHRAE 90.1 requirements.
- .12 Document testing, coordination study and arc flash analysis in a report signed by a Professional Engineer licensed in the Place of Work and authorized by testing company. Include for minimum 3 hard copies and electronic copy of report to be submitted to Consultant for review. Report to include test results with properly plotted curves, identified trouble areas of coordination, extensive comments regarding test results and recommendations on best course of remedial action.

3.06 SHOCK AND ARC FLASH PROTECTION

- .1 Provide for electric shock and arc flash protection as required by local governing electrical code and local governing authorities. Scope of work to be for additional and revised equipment and first level of upstream devices.
- .2 Determine severity of potential exposure, planning safe work practices and selecting personal protective equipment under general guidelines of governing edition of CSA Z462.
- .3 Design safety signs and labels for applications to equipment under general guidelines of ANSI Z535.4.
- .4 Determine arc flash hazard distance and incident energy that workers may be exposed to from electrical equipment under general guidelines of IEEE 1584.
- .5 Incorporate documentation with distribution system and coordination study report.
- .6 Provide labels as required on equipment, meeting applicable standards and codes to satisfaction of Consultant.

END OF SECTION

1 GENERAL

1.01 APPLICATION

- .1 This Section specifies commissioning requirements that are common to electrical works (all Division 26 Sections of Specification), communication works (all Division 27 Sections of Specification), and electronic safety and security works (all Division 28 Sections of Specification). It is a supplement to each Section and is to be read accordingly.

1.02 REFERENCE

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

1.03 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.

1.04 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 one 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 to confirm that pre-functional performance testing has been successfully completed and system or subsystem is ready for functional performance testing and commissioning process to commence.

1.05 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, as further described below.
- .2 Commissioning Agent: commissioning authority who will supervise commissioning process, and who will recommend final acceptance of commissioned electrical work.

- .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 that 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 that 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 that 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 identification as per drawings, and, for each commissioning procedure listed, a column giving expected data as per 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 electrical 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.

1.06 COMMISSIONING AGENT

- .1 A Commissioning Agent will be retained and paid by Owner to perform electrical work commissioning specified in this Section. Cooperate in all respects with Owner's Commissioning Agent.

1.07 QUALITY ASSURANCE

- .1 Commissioning work is to be in accordance with requirements of following:
 - .1 Z320, Building Commissioning Standard & Check Sheets;
 - .2 ASHRAE Guideline 0, The Commissioning Process;
 - .3 Z8001 – Commissioning of Health Care Facilities;
 - .4 Owner designated Commissioning Agent.

1.08 COMMISSIONING OBJECTIVES

- .1 Objectives of commissioning process are as follows:

- .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.

1.09 TESTING EQUIPMENT

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

2 PRODUCTS

Not Used.

3 EXECUTION

3.01 COMMISSIONING

- .1 Commission work in accordance with requirements of this Section and as required by Commissioning Agent.
- .2 Prerequisites to successful completion of commissioning are as follows:
 - .1 submittal of signed start-up and test reports;
 - .2 completion of electrical distribution system testing and coordination study;
 - .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 that 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.

3.02 PHASING OF COMMISSIONING

- .1 Project will be constructed in phases as described in Division 01 Specifications. Phase commissioning work to suit progress and phases of work.

3.03 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.

3.04 SYSTEMS TO BE COMMISSIONED

- .1 Electrical systems to be commissioned include systems as specified in Electrical Divisions of Specification. Specific commissioning procedures are to be as directed by Commissioning Agent. General commissioning procedures for typical equipment and systems include but are not limited to:
 - .1 Distribution Cables:
 - .1 Check for correct cable installation and termination.
 - .2 Check and record cable sizes, types and method of installation.
 - .3 Check and confirm installed cable sizes are of adequate rating, taking into consideration of type of cable, method of installation, correction factors and any other Code requirements.
 - .4 Grounding test to ensure equipment, conduit and cable armour/sheath, if applicable, are properly grounded.
 - .5 Perform tests as required by Commissioning Agent.
 - .2 Transformers:
 - .1 Check and record nameplate data.
 - .2 Check and record sizes and types of primary and secondary protection devices, conductor sizes and types.
 - .3 Test windings on both primary and secondary terminals.
 - .4 Measure primary and secondary winding resistances.
 - .5 Sound level test for different points at 1 m (3.3') away from transformers.
 - .6 Check and record transformer voltage and load current. Check and record transformer on-load temperatures.
 - .7 Perform tests as required by Commissioning Agent.
 - .3 Motor Control Drives:
 - .1 Check and record nameplate data.
 - .2 Check and inspect equipment to ensure it is installed in accordance with manufacturer's recommendations and to Code requirements.
 - .3 Check installation is complete and is ready and safe to carry out testing.
 - .4 Check mechanical operation of switches and breakers.
 - .5 Check connecting bolts are tightened to correct torque values.
 - .6 Check indication lights and control switches for correct functions.
 - .7 Check and set overload relays provided. Set and record overload relays to correct settings.

- .8 Check control functions for proper functioning and connection.
- .9 Check interface contacts for control and indications for proper functioning and connections.
- .10 Check motor running current; readjust overload relays as necessary.
- .11 Coordinate testing and commissioning work with Mechanical Divisions, to ensure full testing and commissioning work is completed to satisfaction of Commissioning Agent.
- .12 Perform tests as required by Commissioning Agent.
- .4 Distribution Panelboards and Branch Circuit Panelboards:
 - .1 Check and record nameplate data.
 - .2 Check and test to verify panelboard directory is correct.
 - .3 Include directory in test records. Directory to contain size of each breaker, equipment served, cable type and size.
 - .4 Check and test voltage drop is within specified limit from service entrance switchboard to branch panelboards.
 - .5 Test branch circuits voltage drop is within requirements.
 - .6 Megger test branch circuits.
 - .7 Perform tests as required by Commissioning Agent.
- .5 Coordination Study and On-Site Testing:
 - .1 Independent Third-Party Testing Agent to prepare coordination study as specified in Specification.
 - .2 Independent Third-Party Testing Agent to carry out on site testing.
 - .3 Check and measure and record prospective fault level at service entrance switchboards, motor control centres, transformers, auto transfer switches, generator switchboard and control panels; distribution panels and branch circuit panelboards.
 - .4 Record and set breakers, fuse ratings, and protection devices to ensure discrimination of electrical distribution system.
 - .5 Provide test records for measured prospective fault level and indicate fault ratings of installed equipment such as switchboards, panels, switches, breakers for above systems to confirm adequacy of fault rating of installed equipment.
 - .6 Perform tests as required by Commissioning Agent.
- .6 Lighting Systems:
 - .1 Check and verify central lighting control systems and dimming systems.

- .2 Check and verify lighting fixtures are connected and switched properly.
- .3 Check and verify automatic controls are connected and functioning properly.
- .4 Check and verify emergency lighting system, including battery lighting system, are connected and functioning properly.
- .5 Carry out lighting level tests as required and directed by Commissioning Agent.
- .6 Perform tests as required by Commissioning Agent.
- .7 Security System and CCTV:
 - .1 Check main panels for proper installation, wiring identification, wire harnessing, and emergency power feed.
 - .2 Test and document each type of alarm from each station, noting station number(s) at which signal has been received.
 - .3 Check field devices for proper operation.
 - .4 Check for integration to other systems.
 - .5 Perform tests as required by Commissioning Agent.
- .8 Fire Alarm System:
 - .1 Check and record nameplate data.
 - .2 Check and report panel enclosure is suitable for environment in which it is installed.
 - .3 Perform system verifications and tests according to CAN/ULC-S536 and S537.
 - .4 Perform tests as required by Commissioning Agent.
- .9 Other Systems:
 - .1 Check and record nameplate data.
 - .2 Perform tests on following systems, where applicable.
 - .1 public address system (paging system);
 - .2 network structured cabling system;
 - .3 electric heat tracing/snow melting.
 - .3 In addition to requirements of Electrical Divisions, test and commission following items:
 - .1 electrical devices supplied in equipment under work of Divisions other than Electrical Divisions;
 - .2 Owner's supplied equipment as noted or directed by Consultant and/or Owner.

- .4 Perform tests as required by Commissioning Agent.

3.05 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.
 - .2 Stage 2: Commissioning work to be performed 12 months after issue of a Certificate of Substantial Performance of the Work 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 first month after issue of a Certificate of Total Performance of the Work.
 - .4 Stage 4: Successful completion of satisfactory equipment/system operation during third month after issue of a Certificate of Total Performance of the Work.
 - .5 Stage 5: Successful seasonal commissioning of building.

3.06 RESPONSIBILITIES OF CONTRACTOR

- .1 During construction phase Contractor is to:
 - .1 prepare and submit an installation schedule which is to include 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 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 third parties to certify correct installation of equipment/systems;
 - .6 under supervision of equipment manufacturers/suppliers, start-up and adjust all equipment to design requirements, and submit start-up sheets which include all 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 all multiple items of smaller equipment, submit sheets to Commissioning Agent, accompany Commissioning Agent for an on-site check 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 in presence of Commissioning Agent and 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's 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 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 visits.
 - .4 correct deficiencies revealed by system checks described above, and, where required, involve equipment manufacturer's/supplier's during corrective actions, and report completion of corrective work;
 - .5 3 months after Substantial Completion of the Work 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

1 GENERAL

1.01 REFERENCES

- .1 Section 26 00 10 applies to and is a part of this Section.
- .2 Section 26 05 00 contains requirements, products, and methods of execution that apply to this Section.

1.02 SUBMITTALS

- .1 Submit shop drawings for equipment and accessories specified in this Section. Shop drawings shall include connection wiring schematic drawings for each system, system design drawings including dimensions and layouts, system riser drawings and copies of manufacturer's component literature sheets.

1.03 PRODUCT COMPATIBILITY

- .1 Lighting controls and luminaires when integrated together for control purposes must be 100% compatible with each other. Coordinate with driver/luminaire manufacturers and lighting control manufacturers to ensure that components are compatible with each other and that interconnections do not affect performance, life or any warranties.
- .2 Lighting control products for a central dimming system shall be 100% compatible with existing central dimming system currently installed in the building by MDR project.

2 PRODUCTS

2.01 CENTRAL DIMMING SYSTEMS

- .1 Central dimming system to be based on Lutron Electronics Co. system, consisting of CSA approved, ULC listed and labelled modular components, compatible with existing Lutron system in the building, including but not limited to following:
 - .1 Lighting management hubs;
 - .2 lighting control modules;
 - .3 control stations of flush wall mounting type, with soft switch sliders and preset controls;
 - .4 sensors;
 - .5 lighting modules;
 - .6 RS232 and ethernet interfaces;
 - .7 emergency lighting interfaces;
 - .8 power packs;
 - .9 wiring in conduit and ancillary devices.
- .2 System to connect to existing lighting control system currently in building. Allow for connection from new lighting management hub to existing.

- .3 System shall be connected to the building communications network for integration into BAS.
- .4 System processor to provide following programming capability:
 - .1 electronically assign each circuit to any zone in dimming system;
 - .2 adjust High-End Trim and Low-End Trim;
 - .3 determine load type for each dimmer;
 - .4 determine Normal/Emergency function of panel and set emergency lighting levels;
 - .5 panel processor to react to changes from control in no more than 20 milliseconds (Update rate of 50 times per second).
- .5 Lighting levels to fade smoothly between scenes at time intervals of 0-59 seconds or 1-60 minutes. Fade time to be separately selectable for each scene and to be indicated by a digital display for current scene. Pressing a scene select button will illuminate corresponding scene LED and simultaneously begin changing barograph levels to reflect currently selected scene. In event that a preset scene with a fade time greater than 5 seconds is initially selected from an 'off' condition, programmed fade time to be temporarily overridden, unless otherwise noted, and lights to fade up to that scene over a 5 second time span.
- .6 Upon loss of normal input power, an emergency lighting interface shall send a signal to immediately turn circuits within that panel to full-on condition when emergency input power is present. System to comply with CSA equivalent requirements to UL 1008.
- .7 Under Emergency input power feed, unless otherwise indicated dimmers to operate at 100% of dimmer output voltage. Under these conditions, dimmers will be in full-on state.
- .8 Under Emergency input power feed, local control stations to be inoperable. Once normal power is restored, lighting zones to revert back to their status prior to emergency condition without requiring any action on part of user.
- .9 Illumination levels to be field-programmable to meet local code requirements for Emergency power conditions. Such options include, but are not limited to, providing a constant minimal light level for emergency circuits during normal operation or providing full function dimming under emergency power.
- .10 Lighting management hubs:
 - .1 CSA approved, ULC listed and labelled.
 - .2 Product: Lutron Light Management Hub.
 - .3 Provided in a pre-assembled NEMA listed enclosure with terminal blocks listed for field wiring.
 - .4 Connects to controls and power panels via RS485.
 - .5 Enables light management software to control and monitor compatible dimming ballasts and ballast modules, power panels, power modules, and window treatments.

- .1 Utilizes Ethernet connectivity to light management computer utilizing one of the following methods:
 - .1 Dedicated network.
 - .2 Dedicated VLAN.
 - .3 Shared network with Building Management System (BMS).
 - .4 Corporate network where managed switches are configured to allow multicasting and use of IGMP.
- .6 Integrates control station devices, power panels, shades, preset lighting controls, and external inputs into a single customizable lighting control system with:
 - .1 Multiple Failsafe Mechanisms:
 - .1 Power failure detection via emergency lighting interface.
 - .2 Protection: Lights go to full on if ballast wires are shorted.
 - .3 Distributed architecture provides fault containment. Single hub failure or loss of power does not compromise lights and shades connected to other lighting management hubs.
 - .2 Manual overrides.
 - .3 Automatic control.
 - .4 Central computer control and monitoring.
 - .5 Integration with BMS via BACnet.
- .7 Furnished with astronomical time clock
- .8 Maintains a backup of the programming in a non-volatile memory capable of lasting more than ten years without power.
- .11 Lighting control modules:
 - .1 Provide lighting control modules as indicated or as required to control the loads as indicated.
 - .2 General Requirements:
 - .1 Listed to UL 508 as industrial control equipment.
 - .2 Delivered and installed as a listed factory-assembled panel.
 - .3 Passively cooled via free-convection, unaided by fans or other means.
 - .4 Mounting: Surface.
 - .5 Connection without interface to wired:

- .1 Occupancy sensors.
- .2 Daylight sensors.
- .3 IR receivers for personal control.
- .6 Connects to lighting management hub via RS485.
- .7 LED status indicators confirm communication with occupancy sensors, daylight sensors, and IR receivers.
- .8 Contact Closure Input:
 - .1 Directly accept contact closure input from a dry contact closure or sold-state output without interface to:
 - .1 Activate scenes.
 - .1 Scene activation from momentary or maintained closure.
 - .2 Enable or disable after hours.
 - .1 Automatic sweep to user-specified level after user-specified time has elapsed.
 - .2 System will provide occupants a visual warning prior to sweeping lights to user-specified level.
 - .3 Occupant can reset timeout by interacting with the lighting system.
 - .3 Activate or deactivate demand response (load shed).
 - .1 Load shed event will reduce lighting load by user-specified amount.
- .9 Emergency Contact Closure Input:
 - .1 Turn all zones to full output during emergency state via direct contact closure input from UL 924 listed emergency lighting interface, security system or fire alarm system.
 - .2 Allow configurable zone response during emergency state.
 - .3 Disable control operation until emergency signal is cleared.
- .10 Supplies power for control link for keypads and control interfaces.
- .11 Distributes sensor data among multiple lighting control modules.
- .12 Capable of being controlled via wireless sensors and controls.
- .3 Switching Lighting Control Modules:
 - .1 Product(s):

- .1 Lutron SoftSwitch Energi Savr Node; Model QSN-4S16-S: 16 A continuous-use per channel.
- .2 Switching:
 - .1 Rated Life of Relay: Typical of 1,000,000 cycles at fully rated 16 A for all lighting loads.
 - .2 Load switched in manner that prevents arcing at mechanical contacts when power is applied to and removed from load circuits.
 - .3 Fully rated output continuous duty for inductive, capacitive, and resistive loads.
 - .4 Module to integrate up to four individually controlled zones.
 - .5 Utilize air gap off, activated when user selects "off" at any control to disconnect the load from line supply.
- .12 Control units:
 - .1 Product: Lutron GRAFIK Eye QS.
 - .2 Provide main units with configuration and quantity of zones as indicated or as required to control the loads as indicated.
 - .3 Connects to lighting management hub via RS485.
 - .4 Finish: As directed by owner
 - .5 Engrave units with button, zone and scene operations as determined by owner.
 - .6 Integrated Wireless Capability:
 - .1 Provide wireless communication inputs for:
 - .1 Occupancy sensors.
 - .2 Daylight sensors.
 - .3 Wireless controller.
 - .2 RF Range: 30 feet (9 m) between sensor and compatible RF receiving device(s).
 - .3 RF Frequency: 434 MHz; operate in FCC governed frequency spectrum for periodic operation; continuous transmission spectrum is not permitted.
 - .7 Preset Lighting Control with Zone Override:
 - .1 Intensity for each zone indicated by means of one illuminated bar graph per zone.
 - .2 User-programmable zone and scene names.
 - .3 Utilize air gap off to disconnect the load from line supply.

- .4 Astronomical time clock and programmer interface provides access to:
 - .1 Scene selections.
 - .2 Fade zone to a level.
 - .3 Fine-tuning of preset levels with scene raise/lower.
 - .4 Lock out scenes and zones.
 - .5 Fine-tuning of light levels with individual zone raise/lower.
 - .6 Terminal block for wired infrared signal input.
 - .7 Enable/disable wall station.
- .5 Light intensity with real time energy savings by digital display.
- .6 Fade time indicated by digital display for current scene while fading.
- .7 Integral wide angle infrared receiver.
- .8 For temporary local overrides, individual raise/lower buttons to allow zones to be adjusted without altering scene values stored in memory.
- .9 Direct Low-Voltage Control of Digital Ballasts and LED drivers (120V Lighting):
 - .1 Electronically link a digital fluorescent lighting ballast to a zone for both dimming and turning on/off.
 - .2 Electronically assign daylight sensors to digital ballasts and line voltage dimmers for proportional daylight harvesting.
 - .3 Single integral controller with Class 1 or Class 2 isolated digital output signal conforming to IEC 60929; capable of direct control without interface.
- .10 Creates daylighting rows independent of control zones.
- .11 Capable of re-zoning without re-wiring using programming display on unit.
- .12 Outputs can be virtually mapped to other device's outputs.
- .13 Zone raise/lower buttons capable of controlling local lighting loads connected to the main unit or remote lighting zones in the system.
- .13 Sensors:
 - .1 Wired Occupancy Sensors:
 - .1 General Requirements:
 - .1 Connects directly to compatible ballasts and modules without the need of a power pack or other interface.
 - .2 Turns off or reduces lighting automatically after reasonable time delay when a room or area is vacated by the last person to occupy the space.

- .3 Accommodates all conditions of space utilization and all irregular work hours and habits.
 - .4 Comply with UL 94.
 - .5 Self-Adaptive Sensors: Continually adjusts sensitivity and timing to ensure optimal lighting control for any use of the space; furnished with field-adjustable controls for time delay and sensitivity to override any adaptive features.
 - .6 Provide capability to:
 - .1 Add additional timeout system-wide without need to make local adjustment on sensor.
 - .2 Group multiple sensors.
 - .7 Power Failure Memory: Settings and learned parameters to be saved in non-volatile memory and not lost should power be interrupted and subsequently restored.
 - .8 Furnished with all necessary mounting hardware and instructions.
 - .9 Class 2 devices.
 - .10 Ceiling-Mounted Sensors: Indicate viewing directions on mounting bracket.
 - .11 Wall-Mounted Sensors: Provide swivel-mount base.
 - .12 Color: White
- .2 Wired Dual Technology Sensors:
- .1 Passive Infrared: Utilize multiple segmented lens, with internal grooves to eliminate dust and residue build-up.
 - .2 Ultrasonic: Utilize an operating frequency of 32 kHz or 40 kHz, crystal-controlled to operate within plus/minus 0.005 percent tolerance.
 - .3 Ceiling-Mounted Sensors: Provide customizable mask to block off unwanted viewing areas.
 - .4 Product:
 - .1 Ceiling-Mounted Dual Technology Sensor; Lutron Model LOS-CDT-2000-WH: Coverage of 2000 square feet (186 sq m) with ceiling height of 8 to 12 feet (2.4 to 3.7 m); 360 degree field of view; self-adaptive
- .3 Provide sensor module as noted on detail, Lutron model QSM2-4W-C.
- .1 Wired Modules:
 - .1 Provide wired inputs for:
 - .1 Occupancy sensors.

- .2 Daylight sensors.
 - .3 IR receivers for personal control.
 - .4 Digital ballast wall stations.
 - .2 Wireless Modules:
 - .1 Provide wireless communication inputs for:
 - .1 Occupancy sensors.
 - .2 Daylight sensors.
 - .3 Wireless controller.
 - .2 RF Range: 30 feet (9 m) between sensor and compatible RF receiving devices.
 - .3 RF Frequency: 434 MHz; operates in FCC governed frequency spectrum for periodic operation; continuous transmission spectrum is not permitted.
 - .3 Communicate sensor information to wired low-voltage digital link for use by compatible devices.
- .14 Modules:
- .1 Provide power interfaces as indicated or as required to control the loads as indicated.
 - .2 General Requirements:
 - .1 Phase independent of control input.
 - .2 Rated for use in air-handling spaces as defined in UL 2043.
 - .3 Utilize air gap off to disconnect the load from line supply.
 - .4 Diagnostics and Service: Replacing power interface does not require re-programming of system or processor.
 - .3 Product:
 - .1 Ten Volt Interface; **Lutron GRX-TVI**: Provides interface for phase control input to provide full 16 A circuit output of switching and 0-10 V low voltage control for compatible fluorescent electronic dimming ballasts or LED drivers.
- .15 RS232 and ethernet interfaces:
- .1 Product: Lutron Model QSE-CI-NWK-E.
 - .2 Provide ability to communicate via Ethernet or RS232 to audio-visual equipment, touchscreens, etc.
 - .3 Provide control of:
 - .1 Light scene selections.

- .2 Fine-tuning of light scene levels with raise/lower.
- .3 Simulate system wall station button presses and releases.
- .4 Provide status monitoring of:
 - .1 Light scene status.
 - .2 Wall station button presses and releases.
 - .3 Wall station LEDs.
- .5 Provide ability to send custom output strings.
- .16 Ancillary Devices:
 - .1 Provide emergency interface and power packs where required to ensure lighting connected to emergency sources will operate as described.
- .17 Submittals:
 - .1 Provide one-line drawings from manufacturer and include with shop drawings. Confirm number of devices and coordinate exact installation locations with Consultant.
- .18 Manufacturer's Services:
 - .1 Manufacturer's authorized technician to provide following:
 - .1 System and network integration consultation (LSC-INT-VISIT);
 - .2 Sensor layout and tuning (LSC-SENS-LT);
 - .3 Onsite performance – verification walkthrough (LSC-WALK);
 - .4 Onsite scene and level tuning (LSC-AF-VISIT);
 - .5 Customer-site solution training (LCS-TRAINING-SP);
 - .2 Include for one of each service above, with the exception of LCS-AF-VISIT, which shall be two.
 - .3 Typically include for minimum 3 onsite visits to:
 - .1 provide above services;
 - .2 ensure that contractor is trained properly to install system;
 - .3 Train Owner's staff on operation, maintenance, and re-programming of system.
- .19 Warranty:
 - .1 Manufacturer's warranty covering 2 years full parts and labour and eight (8) years limited parts warranty to repair and replace defective equipment.

.20 Integration:

- .1 Where system is interconnected to other system and equipment, ensure that it is 100% compatible with respective control systems, relays, and ballasts. Confirm with respective equipment manufacturers and obtain in writing that such integrations are acceptable to each manufacturer.

.21 Acceptable Manufacturers are:

- .1 Lutron Electronics

2.02 WALL BOX DIMMERS

- .1 For applications of standalone basic single control locations: ULC listed and labelled, CSA approved wall box dimmers or ON/OFF/Dimming switch as follows:

- .1 of type and size to suit intended loads;
- .2 air gap accessible without removing faceplate, to meet UL20 and UL1472 short circuit test requirement for snap switches;
- .3 withstand voltage surges up to 600 V and current surges up to 200 A as per ANSI/IEEE C62.41;
- .4 voltage regulated;
- .5 power failure memory;
- .6 LC filtering to minimize RFI;
- .7 snap on faceplate (seamless multi-gang at locations with multiple devices);
- .8 finish to Consultant's direction.

.2 Acceptable manufacturers are:

- .1 Lutron Electronics;
- .2 Acuity Brands;
- .3 Leviton;
- .4 Legrand Wattstopper

2.03 OCCUPANCY SENSORS (STANDARD)

- .1 CSA approved devices to provide automatic control of lighting with following components:

- .1 power and slave packs;
- .2 dual technology occupancy sensors;
- .3 controls and daylight sensors;
- .4 wiring in conduit and mounting hardware.

- .2 Where required, power packs to be self-contained, 120 VAC/24 VDC (or of voltage shown on drawings) transformer relay system. Slave packs to contain isolated relay. System to allow one sensor to control luminaires circuited to both essential power circuits and normal power circuits.

- .3 For applications in general areas: ceiling mounted, dual technology type sensors as follows:
 - .1 combination passive infrared and ultrasonic technologies;
 - .2 when both PIR and ultrasonic technologies detect occupancy, lights turn ON automatically; once lights are ON, detection by either technology holds lights ON until occupancy is no longer detected and time delay elapses;
 - .3 low voltage operation;
 - .4 360° lens area coverage, extending out up to 6 m (20') and area of 92.9 m² (1000 ft²);
 - .5 low profile ceiling mounting design;
 - .6 integral light sensor;
 - .7 adjustable sensitivity and digital time delay;
 - .8 walk-through mode;
 - .9 LED indication of occupancy detection;
 - .10 complete with second output used for VAV boxes application where required;
 - .11 isolated relay for interconnection to auxiliary control systems where required.
- .4 For applications in washrooms and small storage rooms: wall mounted dual technology sensors as follows:
 - .1 wall switch sensor turns lights OFF and ON based on occupancy;
 - .2 factory default operation is for Manual-ON mode, so that users turn light on only when needed;
 - .3 variety of control options including Auto-ON operation, walk-through and test mode; additional settings allow choice of which sensing technologies hold ON or retrigger lighting;
 - .4 colour matched lens and low profile design;
 - .5 wide dispersion lens area coverage, extending out up to 10 m (35') and area of 37 m² (400 ft²);
 - .6 infrared and ultrasonic technologies;
 - .7 adjustable time delays and sensitivity;
 - .8 manual pushbutton operation (override);
 - .9 low voltage or line voltage operation to suit specific applications;
 - .10 complete with required mounting accessories.
- .5 For corridors or wide space coverage: Ceiling mounted, ultrasonic technology type sensors as follows:
 - .1 ultrasonic technologies;
 - .2 when ultrasonic technology detects occupancy, lights turn ON automatically; once lights are ON, detection holds lights ON until occupancy is no longer detected and time delay elapses;
 - .3 low voltage operation;

- .4 corridor applications to include linear lens area coverage, extending out up to 13.5 m (45') in 2 directions;
 - .5 wider spaces applications to include wide dispersion coverage to suit space, up to 200 m² (2200 ft²);
 - .6 low profile ceiling mounting design;
 - .7 integral light sensor;
 - .8 adjustable digital time delay;
 - .9 LED indication of occupancy detection;
 - .10 complete with second output used for VAV boxes application where required;
 - .11 isolated relay for interconnection to auxiliary control systems where required.
-
- .6 Override switches to be wall mounting in single gang recessed outlet boxes.
 - .7 Day light sensors to be provided where required for dimming or controlling lights in areas of windows and atriums/sky lights.
 - .8 Where both normal and emergency power circuited luminaires exist, provide emergency power control unit that allows sensor to control both emergency power circuited luminaires as well as normal power circuited luminaires, and when normal power is lost, forces on emergency power circuited luminaires.
 - .9 Wiring in conduit, mounting hardware and ancillary devices to be provided as per manufacturer's requirements.
 - .10 System to be complete with initial 1 year parts and labour warranty, with additional extended 5 years parts warranty.
 - .11 Include for and arrange for manufacturer's authorized representative to perform on site testing, verification and certification of installed system. Refer to Part 3 installation article for additional requirements.
 - .12 Where sensors are interconnected to dimming system, ensure that they are 100% compatible with respective control systems, dimmers and ballasts. Confirm with respective equipment manufacturers and obtain in writing that such integrations are acceptable to each manufacturer.
 - .13 Where devices are connected to local/central lighting control system, acceptable device manufacturers to be as recommended by manufacturers of the lighting control system.
 - .14 Acceptable manufacturers are:
 - .1 Lutron Electronics;
 - .2 Acuity Brands;
 - .3 Leviton;
 - .4 Legrand Wattstopper.

3 EXECUTION

3.01 INSTALLATION OF CENTRAL LIGHTING CONTROL SYSTEM

- .1 Submit as part of shop drawings, detailed design drawings, single line drawing, block drawings, equipment literature cuts, station finishes, and proposed sequence of operation of entire integrated system. Confirm sequence with Owner prior to start of Work.
- .2 Provide required components for low voltage control of lighting. Where required, integrate system such that dimming system and Mechanical Divisions BAS system can provide control as required. Refer to notes on drawings.
- .3 Dimming control system components and programming to be integrated to occupancy sensors and daylight sensors to perform an integrated lighting control system that provides dimming and ON/OFF control of designated luminaires. Zoning and sequence of operations to be pre-programmed and user friendly in any program changes. Confirm exact zoning and proposed sequence of operation via shop drawings submission stage.
- .4 Provide relay panels for both emergency power and normal power lighting loads being controlled. Initially install tubs during construction work and install interiors during finishing work. Locate panels with dimmer panels as required. Ensure that wall space is sufficient for proper access for service and maintenance as per code requirements. Advise Consultant where spacing is an issue. Provide power, control, and communication wiring in conduit to each panel as required. Confirm exact wiring type and requirements with system manufacturer. Control/communication wiring to generally be daisy chained between panels.
- .5 Confirm emergency sequence of operation with Consultant prior to start of Work and include required hardware and software and interfaces to other integrated systems. Coordinate interfaces with respective system vendors.
- .6 Flush wall mount low voltage switches and mount into recessed wall boxes, complete with a mounting bracket and faceplate for each switch. Confirm finishes with Consultant.
- .7 Locate relay panels adjacent to branch circuit panelboards to which lighting loads are connected. Clearly identify low voltage switching circuits.
- .8 Install dimming controls for areas as identified and confirmed with Consultant. Refer to details on drawings. Circuit dimmers as required and note that no circuits to be loaded greater than rating of dimmers.
- .9 Install panels in locations as shown and as required. Ensure that panels are located to allow sufficient access as per code requirements. Provide required power source and connections to panels. Provide schedule of dimmers in plastic sleeve attached to panel. Connect normal power feeder and emergency power feeder as required. Provide relays as required.
- .10 Include for and arrange for manufacturer's authorized representative to perform programming work and adjustments. Final program features must be approved by Owner.
- .11 Install recessed, wall mounting control stations and wall box dimmers in locations as shown and as required.
- .12 ON/OFF pushbuttons and preset buttons to fade into operation, not instant operation. Set cleaning presets to control circuits at levels as directed by Consultant.

- .13 Luminaire ballasts to be dimmed are to be electronic dimmable types completely compatible with dimming system. Ensure compatibility in writing with respective product manufacturers. Coordinate requirements and connect complete as per manufacturer's instructions.
- .14 Provide wiring in accordance with manufacturer's instructions and approved manufacturer's system wiring diagrams and run wiring in conduit. Wiring to be oversized in accordance with manufacturer's instructions to compensate for voltage drop. Do not splice wiring between control stations or between dimmer/relay panels/racks.
- .15 Install components in accordance with manufacturer's instructions to suit specific installation requirements.
- .16 Confirm exact locations of components prior to roughing-in.
- .17 Ground and bond system as required by local governing electrical code and authority and system manufacturer.
- .18 Integrate system to BAS and other systems, as required. Extend wiring in conduit to required interconnection panels of systems. Typically terminate in junction box adjacent panel, leaving a loop of 3m (10') of un-terminated wiring for final termination by respective system vendors of Mechanical Divisions. Coordinate exact requirements with Mechanical Divisions. Where requested by Mechanical Divisions, provide conduit to terminate at Mechanical Divisions panel.
- .19 Confirm device finishes with Consultant prior to ordering.
- .20 Submit with shop drawings, detailed system wiring diagram and system riser diagram.
- .21 Upon completion of installation, provide following:
 - .1 inspection, testing and verification of system;
 - .2 re-verification of failed or replaced components;
 - .3 signed verification report.
- .22 Testing to include check of operation of each relay panel, dimmer and control station. Adjust and preset devices as required to meet Owner's applications.
- .23 Provide engraved lamaroid identification nameplate for each station, panel and controller. Clearly label each dimmer/panel and label low voltage circuits.
- .24 Confirm nomenclature with Consultant prior to ordering.
- .25 Refer also to testing and verification requirements in Section entitled Electrical Work Analysis and Testing and include applicable requirements.

3.02 INSTALLATION OF WALL BOX DIMMERS

- .1 For applications where integration with central lighting control system is not required, provide flush wall box dimmers in locations and connect to control lighting as indicated. Confirm exact locations prior to roughing-in. Equip each dimmer with a faceplate. Confirm faceplate colour prior to ordering.

- .2 When installation is complete, check and test operation of each dimmer and adjust as required.
- .3 Ensure that each dimmer is properly sized to suit the connected load.

3.03 INSTALLATION OF OCCUPANCY SENSORS

- .1 Prior to submission of Bid, engage sensor manufacturer to review documents to ensure that requirements are included for proper operation and functionality of devices for specific application in compliance with drawing and specification and to ensure complete compatibility of products of integrated lighting control system.
- .2 Integrate shop drawing submission with lighting control panel submission.
- .3 Provide occupancy sensors and daylight sensors and associated devices to control lighting in areas as required. Provide power packs as required with suitable voltage and power ratings. Coordinate installation requirements with installation of lighting control system.
- .4 Exact type of occupancy sensors and type of lenses to be verified by manufacturer/supplier to ensure proper coverage in sensed areas only, and compatibility to interconnected systems. Confirm with respective manufacturers.
- .5 Be responsible for providing, locating, and aiming appropriate sensors in correct location required for complete and proper volumetric coverage within range of coverage(s) of controlled areas per manufacturer's recommendations. Rooms to have 90-100% coverage to completely cover controlled area to accommodate occupancy habits of single or multiple occupants at any location within room(s). Locations and quantities of sensors shown and/or noted are illustrations only and should only be used as guidelines. Provide additional sensors if required to properly and completely cover respective room.
- .6 Verify with manufacturer's factory authorized representative, exact type of sensor to be used in each area, placement of sensors and installation criteria, to best meet requirements of end user. Manufacturer's representative should be consulted for more non-typical installation types. Ensure that sensors connected to dimming system are 100% compatible with dimming system.
- .7 Where luminaires in rooms/areas are feed from normal and emergency power circuits, provide suitable relays and provisions to ensure that operation of luminaires on emergency power are maintained during loss of normal power.
- .8 Proper judgement must be exercised in executing installation so as to ensure that best possible installation in available space and to overcome local difficulties due to space limitations or interference of structural components. Also provide, at Owner's facility, training necessary to familiarize Owner's personnel with operation, use, adjustment, and problem solving diagnosis of occupancy sensing devices and systems.
- .9 Install devices in accordance with manufacturer's instructions. Provide wiring in conduit. Provide required power connections and interconnection to luminaires and power panels. Provide manual switches to override control system in each area/room as shown.
- .10 Confirm finishes of sensors with Consultant prior to ordering.
- .11 Confirm mounting heights with Architect and manufacturer prior to roughing-in and installation.

- .12 Adjust sensitivity and time delays to best suit Owner's furniture layout drawings. Allow for minor adjustments of locations up to 3' [900 mm] of sensors.
- .13 After installation is complete, provide for manufacturer's authorized representative to inspect, test and verify system performance and installation.
- .14 After completion of project and within 30 days after Owner has taken occupancy and furnishings are in place, provide for manufacturer's authorized representative to revisit site to test and make final adjustments.

END OF SECTION

1 GENERAL

1.01 SUBMITTALS

- .1 Submit shop drawings for products specified in this Section.
- .2 Shop drawing to include a dimensioned electrical room layout to demonstrate how the product can fit in existing electrical room and to indicate equipment moving path.

2 PRODUCTS

2.01 DISTRIBUTION TRANSFORMERS (LESS THAN 30KVA)

- .1 Dry type transformers as per drawing schedule, CSA approved and/or ULC listed and labelled, constructed and factory tested in accordance with latest requirements of following:
 - .1 CSA Standard C9 and ANSI-C57.12.01;
 - .2 CAN/CSA C22.2 No. 47;
 - .3 CAN/CSA-C802.2;
 - .4 UL 1561;
 - .5 NEMA TP1;
 - .6 Local governing authority codes and standards.
- .2 Dry type transformers to be K-13 or greater rated, complete with:
 - .1 indoor, air cooled, dry type of the size, rating and capacities as noted on drawings.
 - .2 1.2 kV Class, standard B.I.L.
 - .3 minimum NEMA 3R enclosure with ventilation louvres designed to prevent penetration of water spray from activated sprinklers onto live parts, and gasketed doors and component openings;
 - .4 Class "H", 220°C class, coil insulation, such that winding temperature rise to not exceed 150°C(270°F) and enclosure temperature rise not exceed 65°C(117°F) under full load in a 40°C (104°F) ambient temperature;
 - .5 Ample ventilation openings at top, bottom, front and sides; shielded to prevent access to the live parts;
 - .6 with eye bolts, braces, etc. to enable them to be wall mounted, floor mounted or suspended;
 - .7 top mounted factory painted drip shield;
 - .8 bottom mounted drip tray for wall/ceiling mounted transformers.
- .3 Features for each transformer include:
 - .1 copper windings and copper terminations;
 - .2 core construction consisting of stacked laminations of high permeability silicone steel;
 - .3 vacuum impregnated polyester or epoxy resin;

- .4 lugs or pressure type terminals to suit primary and secondary conductors;
 - .5 up to 15 kVA: two - 5% full capacity taps; one above normal and one below normal; taps located on primary winding;
 - .6 greater than 10 kVA: four - 2-1/2% full capacity taps; two (2) above normal and two (2) below normal; taps located on primary winding;
 - .7 an integral vibration dampening system with anti-vibration pads used between core and enclosure;
 - .8 seismic restraint requirements to suit local governing authority requirements and codes;
 - .9 unless otherwise noted, sound level and basic impulse level to meet CSA C9-02 requirements;
 - .10 efficiency to be 98.6% or better at full load, meeting or exceeding CSA C802.2 and ASHRAE/IES 90.1-1989;
 - .11 factory painted with an ANSI 61 grey enamel finish;
 - .12 aluminum nameplate indicating impedance rating, weight, connection diagram, style and serial number, riveted to front of enclosure in accessible locations.
- .4 Additional features include:
- .1 electrostatic shielding;
 - .2 neutral sized for twice rated current;
 - .3 common mode noise attenuation 60 dB minimum.
- .5 Acceptable manufacturers are:
- .1 Hammond Power Solutions;
 - .2 Delta Group;
 - .3 Schneider Electric;
 - .4 REX Power Magnetics;
 - .5 Bemag Transformer;
 - .6 Siemens;
 - .7 STI Power.

2.02 DISTRIBUTION TRANSFORMERS (OVER 30KVA)

- .1 Dry type transformers as per drawing schedule, CSA approved and/or ULC listed and labelled, constructed and factory tested in accordance with latest requirements of following:
 - .1 CSA Standard C9 and ANSI-C57.12.01;
 - .2 CAN/CSA C22.2 No. 47;
 - .3 CAN/CSA-C802.2
 - .4 UL 1561;
 - .5 NEMA TP1;
 - .6 Local governing authority codes and standards.

- .2 Dry type transformers to be K-13 or greater rated, complete with:
 - .1 indoor, air cooled, dry type of the size, rating and capacities as noted on drawings.
 - .2 1.2 kV Class, standard B.I.L.
 - .3 minimum NEMA 3R enclosure with a rigid end frame, removable plates, a terminal compartment; ventilation louvres designed to prevent penetration of water spray from activated sprinklers onto live parts, and gasketed doors and component openings;
 - .4 Class "H", 220°C class, silicone type coil insulation, such that winding temperature rise to not exceed 150C°(270F°) and enclosure temperature rise not exceed 65C°(117F°) under full load in a 40°C (104°F) ambient temperature;
 - .5 Ample ventilation openings at top, bottom, front and sides; shielded to prevent access to the live parts;
 - .6 with eye bolts, braces, etc. to enable them to be wall mounted, floor mounted or suspended;
 - .7 top mounted factory painted drip shield;
 - .8 bottom mounted drip tray for wall/ceiling mounted transformers.
- .3 Features for each transformer include:
 - .1 copper windings and copper terminations;
 - .2 core construction consisting of stacked laminations of high permeability silicone steel;
 - .3 vacuum impregnated polyester or epoxy resin;
 - .4 lugs or pressure type terminals to suit primary and secondary conductors;
 - .5 four (4) 2-1/2% full capacity taps; two (2) above normal and two (2) below normal, with wires brought out to tap board; taps located on primary winding; provide tap changing board with links;
 - .6 an integral vibration dampening system with anti-vibration pads used between core and enclosure;
 - .7 unless otherwise noted, sound level and basic impulse level to meet CSA C9 requirements; unless otherwise noted, transformers 300 kVA and larger to have noise level 3dB below CSA C9 requirements;
 - .8 efficiency to be 98.6% or better at full load, meeting or exceeding CSA C802.2 and ASHRAE/IES 90.1-1989;
 - .9 factory painted with an ANSI 61 grey enamel finish;
 - .10 aluminum nameplate indicating impedance rating, weight, connection diagram, style and serial number, riveted to front of enclosure in accessible locations.
- .4 Additional features include:

- .1 electrostatic shielding;
- .2 neutral sized for twice rated current;
- .3 common mode noise attenuation 60 dB minimum.
- .5 Acceptable manufacturers are:
 - .1 Hammond Power Solutions;
 - .2 Delta Group;
 - .3 Schneider Electric;
 - .4 REX Power Magnetics;
 - .5 Bemag Transformer;
 - .6 Siemens;
 - .7 STI Power.

3 EXECUTION

3.01 INSTALLATION OF DISTRIBUTION TRANSFORMERS

- .1 Locate transformers into position. Ensure adequate clearance is provided as per code requirements and as required for access for operation and maintenance. Comply with manufacturer's instructions and recommendations.
- .2 All transformers shall be mounted with minimum 6mm thick neoprene isolation pads. Isolation pad shall be crossed, double ribbed.
- .3 Secure transformers smaller than 75 KVA in place on an angle wall mounting bracket support assembly located approximately 300 mm (12") below ceiling. Provide support assembly and adequately secure to wall and/or ceiling construction.
- .4 Transformers rated larger than 75 kVA shall be floor mounted. External, anti-vibration isolation mountings shall be supplied and installed for all floor mounted transformers, on minimum 4" high concrete housekeeping pads.
- .5 Ensure that transformers are equipped with lugs or connections suitable for primary and secondary connections. Isolate primary and secondary connections from transformer enclosures by means of 300 mm - 450 mm (12" to 18") of liquid-tight flexible conduit.
- .6 Ground and bond equipment to ground electrode grids as per local governing electrical code and inspection authority requirements. Refer also requirements of Section entitled – Grounding and Bonding.
- .7 Provide engraved Lamacoid nameplates and warning signs with nomenclature reviewed with Consultant.
- .8 Transformer nameplates shall be installed in an accessible location for viewing.
- .9 When installation is complete, test and check secondary voltages. Make all required adjustments and submit to Consultant a test report indicating secondary voltage readings and any adjustments made to achieve proper voltages. Furthermore, when building is in normal use, re-check voltages and make any required adjustments.
- .10 Refer to testing, coordination and verification requirements in Section entitled Electrical Work Analysis and Testing and include applicable requirements.

END OF SECTION

1 GENERAL

1.01 SUBMITTALS

- .1 Submit shop drawings for products specified in this Section.

1.02 BREAKERS

- .1 Size breakers as per drawings and/or schedules, but in absence of direction, size breakers to suit intended application, to suit coordination study requirements and in accordance with local governing electrical safety code. Breaker sizes should be clear. If there are any questions, contractor to provide questions to consultant in form of RFI.
- .2 All breakers with frame sizes of 200A or greater shall have an electronic trip unit with LSI settings at a minimum.
- .3 For breakers with solid state adjustable trip units, set trip units at ratings as per coordination study as required for proper coordination. Provide ground fault alarm and trip functions at breaker trip rating above 600A, as coordinated with results of coordination study and as confirmed with Consultant.
- .4 Breaker trip units shall be self-powered and shall not require an external power source for proper operation. Battery use for protection functions is not acceptable.
- .5 Trip units shall have visual indication of the reason for tripping. Trip indicators shall be latching type and remain in position until manually reset
- .6 Thermal motor breakers are not acceptable in any panelboards.

2 PRODUCTS

2.01 PANELBOARDS GENERAL REQUIREMENTS

- .1 Note that panelboards may also be referenced simply as panels.
- .2 Emergency panelboards shall be Pantone 335 C (green) or approved equivalent.
- .3 UPS panelboards shall be Pantone 285 C (blue) or approved equivalent.
- .4 Panelboards shall be equipped with a hinged front cover.
- .5 Circuit breakers shall be of the bolt-on type. Multi-pole breakers shall come factory assembled. All interrupting ratings shall exceed available fault levels as determined by coordination studies.
- .6 All circuit breakers shall be thermal magnetic type. Tandem double density (mini) circuit breakers are not acceptable.
- .7 Panelboards are to be mounted so that the top of the panels are located 2m (78 in) above finished floor.
- .8 Panelboard directories shall be typewritten using the templates provided by the University. Directories shall indicate the final room numbers.

- .9 The appropriate bus mounting hardware for these spaces shall also be installed within the panelboard for all spaces where future breakers can be installed.
- .10 Filler plates shall be provided on all blank breaker spaces.
- .11 If panelboard is equipped with an integral main breaker or switch, it shall be of the 'service entrance' type and be appropriately barriered from the downstream branch circuits.
- .12 All indoor surface mount panelboards shall be NEMA 1 rated, with drip hood/shield, and shall use rain tight connectors and fittings.

2.02 DISTRIBUTION PANELBOARDS

- .1 Distribution panelboards (DP) shall be double row. When the DP is an integral part of a switchgear line-up, the panelboard shall extend the entire height of the switchgear cell and contain spaces for breakers for that entire height.
- .2 Lamacoids of size B (refer to Section 26 05 00 Article 2.10 Identification Nameplates) shall be installed next to each circuit breaker, detailing the branch panelboard or equipment it is feeding, including room number where the feeder terminates.
- .3 All DP Panelboards shall be equipped with solid core 80mA secondary CTs with accuracy consistent with the NRG type multipoint meter requirements in the Meter requirement summary table below on each phase of each circuit. CT primary ratings shall match the associated breaker trip rating for each circuit. All CT secondary wiring shall be brought out to a separate enclosure adjacent to the panel and terminated on a shorting style terminal block. The terminals shall be permanently labelled for future metering connections.
- .4 Factory assembled dead front panelboards with the sizes and type of breakers as per drawing schedules, manufactured to CSA Standard C22.2. No. 29. Generally, interrupting capacities are scheduled, but in absence of direction, provide to capacity to suit intended application to suit local governing electrical code.
- .5 Locate both main lugs and neutral bar at same end. Shield main lugs through a removable cover. Identify each circuit breaker adjacent breaker handle. Refer to Part 1 for requirements of breakers to be provided with solid-state adjustable trip units. Group mount circuit breakers.
- .6 Panelboard interior to have three flat bus bars stacked and aligned vertically with insulators laminated between phases. Insulators support and provide phase isolation to entire length of bus. A solidly bonded equipment ground bar and a neutral bar to be provided.
- .7 Bus bars (phases, grounds and neutrals) to be hard drawn electrical grade copper, silver plated and extend throughout panel. Neutral bus shall be rated 200% of main bus rating.
- .8 Interior trim to be of dead-front construction to shield user from energized parts. Main circuit breaker and main lug interiors to be field convertible for top or bottom incoming feed.
- .9 Include main breakers for panelboards as scheduled. If DP panelboard is equipped with an integral main breaker or switch, it shall be of the 'service entrance' type and be appropriately barriered from the downstream branch circuits.

- .10 Circuit breakers shall be ambient compensated type, calibrated at 40°C and be of the bolt-on type, without any plug-in connections. Multi-pole breakers shall have common trip.
- .11 All interrupting ratings shall exceed available fault level as determined by coordination studies.
- .12 Panelboard boxes to be constructed of code gauge, hot zinc dipped galvanized steel constructed in accordance with UL 50 requirements, complete with removable ends and wiring gutter space on sides in accordance with CSA requirements.
- .13 Floor mounted enclosures to be free-standing type, reinforced as required to provide adequate strength.
- .14 Enclosures located in climate-controlled areas to be minimum NEMA 1. Surface mounted panelboards to be complete with drip shield. Ventilation louvers to be designed to prevent penetration of water spray onto live components. Conduit entries to be sealed watertight. Units to be factory painted in ANSI 61 grey enamel. Recessed backboxes (tubs) need not be finished painted.
- .15 Panelboards sized up to 600A to be complete with doors, latches, and keyed alike locks. Locks to be cylindrical tumbler type with larger enclosures requiring sliding vault locks with 3-point latching. Supply 2 keys with each lock.
- .16 Panelboards to include for future breaker provisions as noted on schedules. Make provision for space for breakers, bussing for full panel size and where spare breakers are scheduled, breakers with required connector kits. Unused spaces provided, unless otherwise specified, to be fully equipped for future devices, including appropriate connectors and mounting hardware.
- .17 Panelboards as scheduled to be complete with integral surge protective devices (SPDs). Unit to be factory installed and connected onto bussing through integral breaker as recommended by manufacturer. Unit to include diagnostic package with status indicators on each phase, audible alarm and Form C alarm contacts. Unit to be maintenance free. SPD features include:
 - .1 Type 1;
 - .2 in accordance with ANSI/UL 1449 3rd Edition, IEEE C62.41, C62.45, UL 1283, and CSA Standards;
 - .3 maximum voltage protection rating to not exceed 700 V (120/208 V) or 1500 V (600/347V); (L-N, L-G, N-G);
 - .4 minimum nominal discharge current rating of 10 kA;
 - .5 minimum short circuit current rating of 100 kA;
 - .6 peak surge current 150 KA per phase;
 - .7 indicator LED on units to identify protection integrity status of metal-oxide varistors; indicator to be visible on front of panelboard;
 - .8 high-performance EMI/RFI noise rejection filter;
 - .9 standard manufacturer's minimum 5 years parts and labour warranty.
- .18 Panelboards shall be provided with non-ferrous plates for single conductor entry as required.

- .19 Splitter troughs incorporated in the panelboard shall be complete with copper bus bars the length of the trough.
- .20 No plug-in connections of any type are acceptable within a panelboard.
- .21 Acceptable manufacturers are Schneider Electric (Square D), Siemens Electric Ltd. and Eaton (Cutler-Hammer).

2.03 METER REQUIREMENTS

- .1 All meters shall be bi-directional.
- .2 All meter front panel instantaneous-value update intervals shall be no greater than once every 60 seconds.
- .3 All meters shall have an operating temperature range between -20°C and +40°C.
- .4 All RMS measurements shall be True RMS, not Average RMS.
- .5 All meters shall have a digital display allowing for configuration of settings and displaying instantaneous metering values at a minimum.
- .6 All max/min values shall be individually resettable, both locally and remotely through the associated communication protocols.
- .7 Top of meter display shall be installed no higher than 1.9 m (75 in) from the floor. Bottom of the meter display shall be installed no lower than 1.2 m (47 in) from the floor.
- .8 Meters may be installed within enclosures provided the preceding height requirements are preserved, and no tools are required to open the enclosure.
- .9 Meter accessories
 - .1 Metering CTs shall be solid core type. Split core type may be used only in retrofit applications where the primary value of the CT ratio is greater than 100A.
 - .2 If PTs are required, they shall be metering grade (CPTs are not acceptable).
 - .3 Primary CT rating shall match (as close as practicable) the ampacity of the circuit it is measuring.
 - .4 If required, potential transformers to meters shall be "primary" fused with HRC type fuses. Fuses shall be located inside a compartment that is accessible without exposure to primary conductors. PT secondary voltage shall be 120V.
 - .5 Meters shall be powered from a separate power supply or control power transformer and shall not be powered from the metering PTs.
 - .6 All meters' monitoring ATs (Automatic Transfer Switch) shall be powered from a UPS connected to the load side of the ATS, capable of powering the meter through a source transition to an emergency source.
- .10 Meter requirement summary table

	NRG Multi Point	NRG Single Point	PQ	PQ+
Communication Protocols	MODBUS/ TCP BACnet IP	MODBUS/ TCP BACnet IP	MODBUS/ TCP ION DNP3	MODBUS/ TCP ION DNP3
Time Sync Protocols	-	SNTP	NTP/SNTP IRIG-B PTP	NTP/SNTP IRIG-B PTP
Min Sample Rate (samples/cycle)	64	128	256	1024
CT Accuracy Class Meter	0.5	0.2	0.2	0.1
CT Secondary Ratio	80mA	5A	5A	5A
Minimum Connected CT Accuracy Class	1.0 ^a	1.0 ^a	0.5	0.3
Voltage Sensing Maximum	300VAC	600VAC	600VAC	600VAC
Measurements:				
kW, kWh, kVA, kVAh, kVAr, kVArh, Vrms, Irms and PF	X	X	X	X
THD & TDD	-	X	X	X
Individual Harmonics	-	up to 63rd	up to 63rd	up to 63rd
kW max/min & kVA max/min	-	X	X	X
kVAr max/min	-	X	X	X
Vrms max/min & Irms max/min	-	X	X	X
PF max/min	-	X	X	X
Voltage Sag/Swell	-	-	X	X
Flicker	-	-	-	X
Inter-harmonic Distortions	-	-	-	X
Symmetrical Components	-	-	-	X
Phasor Display	-	X	X	X
Event Logging	-	X	X	X
Waveform Capture	-	-	X	X
Disturbance Detection	-	-	-	X
Local Data Storage Duration	-	to 30 days	to 30 days	to 30 days
Digital Inputs & Digital Outputs	-	2	4	6
Analog Inputs (4-20mA)	-	-	-	2
Control Voltage	110-130VAC	100-240VAC	100-400VAC 110-150VDC	100-400VAC 110-150VDC
^a If meter is used for billing purposes, accuracy requirements must comply with Measurement Canada Standards.				

3 EXECUTION

3.01 INSTALLATION OF DISTRIBUTION PANELBOARDS

- .1 Provide distribution panelboards and install into locations and connect complete. Ensure adequate clearance is provided as per code requirements and as required for access for operation and maintenance.
- .2 Install floor mounted panelboards on concrete housekeeping pads. Provide seismic restraints as required by local governing authorities and codes. Surface wall mount other panelboards, unless otherwise noted, independent of connecting conduit.
- .3 Equip each panelboard with suitable lugs to accommodate main and branch conductors as scheduled. Identify panelboard and breakers with Lamacoid identification nameplate with nomenclature to Consultant's approval.
- .4 Panelboard directories shall be typewritten, using U of T'S standard panel schedule template (can be found online <https://www.fs.utoronto.ca/projects/design-standards-and-project-forms/>).
- .5 Ground and bond equipment as per local governing electrical code and inspection authority requirements. Refer also to requirements of grounding and bonding article.
- .6 Additionally, refer to testing, coordination and verification requirements in Section entitled Electrical Work Analysis and Testing and include applicable requirements.

3.02 INSTALLATION OF INTEGRAL SPDs

- .1 Obtain required training from manufacturer's representative on any special installation procedures. Install units in accordance with manufacturer's instructions to suit specific installation requirements.
- .2 Coordinate panelboards configuration to install SPD units for applications of integral mounting. Install dedicated disconnect/breaker device of type and rating in accordance with SPD manufacturer's requirements. Connect complete to SPD and bussing.
- .3 Ensure that MOV condition LED indicator is visible from front of board/panel.
- .4 Ground and bond components as per local electrical code requirements. Refer also to requirements of grounding and bonding article.

3.03 INSTALLATION OF CHECK METERING

- .1 Provide meters, sockets and ancillary devices and connect complete.
- .2 Install components in accordance with manufacturer's instructions to suit specific installation requirements.
- .3 Install current transformers to encircle conductors.
- .4 Install wiring in conduit and required devices in accordance with recommendations of product manufacturers.
- .5 Test and adjust to manufacturer's requirements.

- .6 Obtain required approvals/inspections for metering subject to local governing authority regulations.

3.04 TRAINING OF METERING

- .1 Manufacturer's trained technician to perform onsite training of each user (including the provision of user guides) prior to project completion to ensure that users are properly trained in the operation and maintenances of system.
- .2 Refer to Instructions to Owner specified in Section entitled Electrical Work General Instructions.

END OF SECTION

1 GENERAL

1.01 SUBMITTALS

- .1 Submit shop drawings for products specified in this Section.

1.02 BREAKERS

- .1 Size breakers as per drawings and/or schedules, but in absence of direction, size breakers to suit intended application, to suit coordination study requirements and in accordance with local governing electrical safety code. Breaker sizes should be clear. If there are any questions, contractor to provide questions to consultant in form of RFI.
- .2 Thermal motor breakers are not acceptable in any panelboards.

2 PRODUCTS

2.01 PANELBOARDS GENERAL REQUIREMENTS

- .1 Note that panelboards may also be referenced simply as panels.
- .2 Emergency panelboards shall be Pantone 335 C (green) or approved equivalent.
- .3 UPS panelboards shall be Pantone 285 C (blue) or approved equivalent.
- .4 Panelboards shall be equipped with a hinged front cover.
- .5 Circuit breakers shall be of the bolt-on type. Multi-pole breakers shall come factory assembled. All interrupting ratings shall exceed available fault levels as determined by coordination studies.
- .6 All circuit breakers shall be thermal magnetic type. Tandem double density (mini) circuit breakers are not acceptable.
- .7 Panelboards are to be mounted so that the top of the panels are located 2m (78 in) above finished floor.
- .8 Panelboard directories shall be typewritten using the templates provided by the University. Directories shall indicate the final room numbers.
- .9 The appropriate bus mounting hardware for these spaces shall also be installed within the panelboard for all spaces where future breakers can be installed.
- .10 Filler plates shall be provided on all blank breaker spaces.
- .11 If panelboard is equipped with an integral main breaker or switch, it shall be of the 'service entrance' type and be appropriately barriered from the downstream branch circuits.
- .12 All indoor surface mount panelboards shall be NEMA 1 rated, with drip hood/shield, and shall use rain tight connectors and fittings.

2.02 BRANCH CIRCUIT PANELBOARDS

- .1 Factory assembled dead front panelboards as per schedules, manufactured to CSA Standard C22.2 No. 29 and local governing electrical code, and designed for sequence phase connection of branch circuit breakers.
- .2 As scheduled, panelboards are of types:
 - .1 120/208 V, 3-phase and single phase panelboards, bolt-on moulded case circuit breakers with a minimum interrupting capacity of 10 KA symmetrical at 208 V, unless otherwise scheduled.
 - .2 347/600 V, 3-phase panelboards, bolt-on moulded case circuit breakers with an interrupting capacity as scheduled or in absence of direction to be of capacity for intended application to local governing electrical code requirements.
 - .3 Interrupting capacity of panelboards shall be evaluated by the power system study shop drawing. If the interrupting capacity as scheduled does not pass evaluation, panelboards shall be ordered with higher interrupting capacity as recommended by the power system study.
 - .4 Where panelboards are schedule to include series rated provisions, provide breakers as recommended by panel manufacturer.
- .3 Where ground fault circuit interrupting (GFCI) type breakers are required by code and/or scheduled, provide ground fault, CSA Class "A", Group 1, combination thermal magnetic bolt-on circuit breakers with solid-state ground fault interrupters.
- .4 Panelboards to be equipped with one (1) continuous bus bar per phase. Each bus bar to have sequentially phased branch circuit connectors limited to bolt-on branch circuit breakers. Bussing to be fully rated and of plated copper construction.
- .5 Panelboards are to be complete with:
 - .1 NEMA 1, box constructed of code gauge galvanized steel with removable box ends, wiring gutter space on sides; conduit entries sealed water-tight;
 - .2 dead-front construction to shield user from energized parts;
 - .3 enclosure constructed of code gauge, hot zinc dipped galvanized steel constructed in accordance with UL 50 requirements; trim for flush or surface wall mounting as shown; front panel to not be removable with the door locked;
 - .4 hinged door with concealed fasteners, concealed hinge, chrome plated door latch and keyed alike lock with two keys;
 - .5 a steel frame holder and circuit directory card protected by clear acetate and secured to back of door, and Mylar circuit breaker identification strips;
 - .6 drip shield for surface mounted panelboards;
 - .7 copper buses extend the full length of the panel;
 - .8 200% sized neutral bus;
 - .9 solidly bonded equipment copper ground bar;
 - .10 high strength, set screw type, anti-turning wire connectors;
 - .11 current-carrying parts be insulated from ground and phase-to-phase by high dielectric strength thermoplastic;

- .12 filler plates covering unused mounting space;
- .13 non-automatic or automatic main breaker to function as an isolating switch, where shown and as required;
- .14 ground fault circuit interrupting (GFCI) type breakers to feed devices as scheduled and for applications required by local governing codes;
- .6 Panels, doors and trim are to be factory painted with ANSI 61 grey enamel finish, unless otherwise as required. Recessed backboxes (tubs) need not be finished painted.
- .7 Circuit breakers shall be ambient compensated type, calibrated at 40°C and be of the bolt-on type, without any plug-in connections. Multi-pole breakers shall have common trip.
- .8 Circuit breakers for 120/208 Volt application shall have a minimum symmetrical interrupting rating of 10,000 Amps. For 600 Volt applications, the rating shall be minimum 35,000 Amps. All interrupting ratings shall exceed available fault level as determined by coordination studies.
- .9 Tandem double density circuit breakers are not acceptable.
- .10 Equip breakers of frame size 225 amperes and greater, with solid state adjustable trip units.
- .11 Equip circuit breakers connected to dedicated equipment or devices with handle locks.
- .12 Include spare breakers as sized on schedules and future breaker provisions as noted on schedules. Future breaker provisions to include space for breakers, bussing for full panel size and where future breaker sizes are scheduled, required breaker connector kits.
- .13 Unless otherwise scheduled or noted, include a of minimum three (3) 15A-1P breakers to feed BAS panels.
- .14 Branch circuit panelboards as scheduled to be complete with integral surge protective devices (SPDs). SPD unit to be factory installed and connected onto bussing through integral breaker as recommended by manufacturer. SPD features include:
 - .1 in accordance with ANSI/UL 1449 3rd Edition, IEEE C62.41, C62.45, UL 1283, and CSA Standards;
 - .2 Type 1;
 - .3 maximum voltage protection rating to not exceed 700 V (120/208 V) (L-N, L-G, N-G);
 - .4 minimum nominal discharge current rating of 10 kA;
 - .5 minimum short circuit current rating of 100 kA;
 - .6 minimum peak surge current 100 KA per phase;
 - .7 high-performance EMI/RFI noise rejection filter;
 - .8 indicator LED on units to identify protection integrity status of metal-oxide varistors; indicator to be visible on front of panelboards;
 - .9 diagnostic package with status indicators on each phase;
 - .10 audible alarm;
 - .11 Form C alarm contacts;

- .12 maintenance free and not require any user intervention throughout its life;
- .13 standard manufacturer's minimum 5 years parts and labour warranty.
- .15 Acceptable manufacturers are Schneider Electric (Square D), Siemens Electric Ltd. and Eaton (Cutler-Hammer).

3 EXECUTION

3.01 INSTALLATION OF PANELBOARDS

- .1 Provide factory assembled branch circuit panelboards and install into locations and connect complete. Ensure adequate clearance is provided as per code requirements and as required for access for operation and maintenance. Load panels with breakers as scheduled.
- .2 Support cabinets and enclosures independent of connecting conduit, and accurately install with reference to wall finishes.
- .3 Equip panelboards with suitable lugs or provisions to accommodate main and branch conductors scheduled.
- .4 Coordinate with Mechanical Division trades and Consultant to determine extra mechanical loads and BAS panels requiring use of specified additional 15A circuits and connect complete.
- .5 Ground and bond equipment as per local governing electrical code and inspection authority requirements. Refer also requirements of Section entitled – Grounding and Bonding.
- .6 Turn over to Owner, prior to application for a Certificate of Substantial Performance of Work, a quantity of two (2) panelboard cabinet or enclosure keys per panelboard.
- .7 Where two (2) or more panelboards are installed in one (1) cabinet, equip panelboards with double lugs and increase gutter capacity to accommodate additional cabling.
- .8 Identify panelboard breakers in a permanent manner and complete typed panelboard circuit directories, using UofT standard panel schedule templates and identifying circuit number, type and location of loads supplied from each breaker, to Consultant's approval. Directories shall indicate the final room numbers as designated by Office of Space Management (OSM).
- .9 Include for spaces for future breakers, spare breakers and additional breakers for miscellaneous mechanical loads are included as per schedules and as specified.
- .10 Provide filler plates on all blank breaker space.
- .11 Test and verify ground fault circuit interrupting breakers as follows:
 - .1 demonstrate in presence of Consultant that protected circuits will "trip" when a simulated ground fault is applied to "load" side of each circuit breaker/ground fault interrupter combination;

- .2 megger load side neutral on GFCI protected branch circuits to ensure that neutral is not grounded on load side of GFCI;
 - .3 verify GFCI operation with a temporary load (100 watt lamp in an insulated socket with pigtail leads);
 - .4 provide a written report confirming that tests have been performed and that system is functioning properly.
- .12 Ground and bond panel as per local electrical code requirements. Refer also to requirements of grounding and bonding article.
 - .13 Panelboards are to be mounted so that the top of the panels are 2000mm (6'-6") above finished floor.
 - .14 Provide two 1" empty conduits from each flush mounted panelboard to the ceiling spaces above and below for future installation of wiring. The conduits shall terminate in junction boxes with fish wires.
 - .15 Panelboards shall be identified as panel name, voltage and current rating, and the designation of the source of power supplying the panelboard.

Example: "065-NLP-B1-02-1A 120/208V 200A 3PH 4W Fed from 065-NDP-B1-02-1A".
 - .16 Panelboard identification shall be on engraved lamacoid plate, white letters ½" high on black background for normal power panels, white letters on green background for emergency supply panelboards. Lamacoid plates shall be fastened to the outside of the panelboard with stainless steel screws. Pen size for lettering shall be 1 mm minimum.
 - .17 Additionally, refer to testing, coordination and verification requirements in Section entitled Electrical Work Analysis and Testing and include applicable requirements.

3.02 INSTALLATION OF INTEGRAL SPDs

- .1 Obtain required training from manufacturer's representative on any special installation procedures. Install units in accordance with manufacturer's instructions to suit specific installation requirements.
- .2 Coordinate panelboards configuration to install SPD units for applications of integral mounting. Install dedicated disconnect/breaker device of type and rating in accordance with SPD manufacturer's requirements. Connect complete to SPD and bussing.
- .3 Ensure that MOV condition LED indicator is visible from front of board/panel.
- .4 Ground and bond components as per local electrical code requirements. Refer also to requirements of grounding and bonding article.

END OF SECTION

1 GENERAL

1.01 SUBMITTALS

- .1 Submit shop drawings for products specified in this Section.
- .2 Submit samples of each typical wiring device, faceplates, finishes and colours. Mount to sample board, clearly labelling devices and finishes. Submit for review by Owner and Consultant. Do not order any device unless finishes have been reviewed and approved by Consultant.

2 PRODUCTS

2.01 SWITCHES & RECEPTACLES

- .1 Switches to be CSA approved, ULC listed and labelled, premium specification grade, back and side wired, A.C. 20 ampere, 120-277 V switches. Switches to include steel-nickel plated bridge, nylon rocker, one piece rivetless copper alloy spring contact arm and terminal plate, silver cadmium oxide contacts, brass binding head screws, one piece integral grounding terminal and stainless steel automatic grounding clips.
 - .1 Provide single way, 2-way, 3-way, and pilot type to suit specific application requirements.
 - .2 Provide toggle type switches, except where required in washroom or corridors which shall be key operated.
- .2 The dimmers up to 1500W shall have linear slide control, white finish and lamp debuzzing coil in aluminium enclosure, equal to Lutron 'Nova' series.
- .3 Receptacles to be CSA approved, ULC listed, certified, and labelled, extra heavy duty, premium specification grade (unless otherwise hospital grade as required), back and side wired, flush, nylon face/body construction devices complete with one-piece nickel-plated brass mounting strip with integral grounding clips, ground retention clips, nickel-plated brass wiring clamps with nickel-plated brass screws, front circuit identification area and reinforced thermoplastic base.
 - .1 Duplex U-ground, 15/20 ampere, 125 V, 2-pole, 3-wire grounding receptacles.
 - .2 Duplex U-ground, 15 ampere, 125 V, 2-pole, 3-wire, tamper-resistant (safety shutter) receptacles.
 - .3 Single, 20 ampere, 125 V, 2-pole 3-wire grounding receptacles.
 - .4 Single, 20 ampere, 250 V, 2-pole 3-wire grounding receptacle.
 - .5 15/20 ampere, 125 V, duplex, ULC Class "A", Group One, tamper resistant, weather resistant ground fault circuit interrupting receptacles complete with red ground fault LED and 10ka short circuit current rating.
 - .6 Single, 20 ampere, 125 V, 2-pole, 3-wire grounding twist lock receptacle.

- .7 Single, 20 ampere, 250 V, 2-pole, 3-wire grounding twist lock receptacle.
- .8 Where noted that 20 A receptacles are required, include for "T" slot type of respective series of receptacles.
- .4 Special switches and receptacles not specified above are to be specified on drawings. Low voltage lighting controls are specified in Section entitled Lighting Control.
- .5 Acceptable manufacturers are:
 - .1 Hubbell Canada Inc.;
 - .2 Cooper Wiring Devices (Arrow Hart);
 - .3 Legrand - Pass & Seymour;
 - .4 Leviton.

2.02 FACEPLATES

- .1 Type 302, multiple gang, specification grade 1 mm (0.032") thick stainless steel, satin, brushed or natural finish, complete with a peel off protective plastic film, and stainless steel screws.
- .2 Wall plates for surface mounted devices in unfinished areas shall be metal covers for F.S. type boxes.
- .3 NEMA 3R rated, CSA approved, ULC listed and labelled, single gang, vertical/horizontal mounting, weather-proof in-use, gasketed with lift cover, cast aluminium faceplates for standard duplex receptacles in wet / outdoor locations.
- .4 NEMA 3R rated, CSA approved, ULC listed and labelled, single gang, vertical/horizontal mounting, weather-proof in-use, gasketed with lift cover, cast aluminium faceplates for GFI receptacles in wet / outdoor locations.
- .5 NEMA 3R rated, CSA approved, ULC listed and labelled, single gang, vertical mounting, weather proof in-use, gasketed, clear bubble plate, silicone rubber faceplates for standard AC toggle switches in wet / outdoor locations.
- .6 The A.V. and computer outlet wall plates shall be provided as required by Owner's Enterprise Infrastructure Solutions (EIS).
- .7 The telephone outlet wall plates shall be provided as required by Owner's Enterprise Infrastructure Solutions (EIS) standards.
- .8 Colour of special switch and receptacle faceplates to be as specified below:
 - .1 Light switches and receptacles on normal power shall be white.
 - .2 Light switches and receptacles on emergency power shall be red.
 - .3 Light switches and receptacles on UPS power shall be blue.
 - .4 Isolated ground receptacles shall be orange.
- .9 Provide cover plates for flush mounted manual starters.
- .10 Acceptable manufacturers are as per switches and receptacles.

2.03 POKE-THRU FLOOR BOX

- .1 CSA approved, UL scrub water compliant, ULC listed and labelled, for two (2) hour fire resistance rating, fully assembled, flush unwired poke through floor box as follows:
 - .1 150 mm (6") poke through device installs into a 6" (152mm) to a 6 1/8" (155mm) diameter hole;
 - .2 for recessed floor box application in an above-grade concrete floor that has access in the ceiling of the floor below;
 - .3 pre-pour sleeve - creates a cast-in-place core hole that allows the contractor to position poke-thru units before concrete is poured;
 - .4 three (3) bottom feed compartments: (1) 1/2-Gang Pass-Through Housing Assembly, (1) 1-Gang Pass-Through Housing Assembly, and (1) 1/2-Gang 3/4" Conduit Housing Assembly that is attached with a junction box;
 - .5 complete with a disposable sheet metal cover, and three (3) empty compartments are recessed 4" (102mm) below the floor surface level and can be configured to accept power, data, or audio/video devices;
 - .6 provide tamper-resistant surface style cover assembly – low profile die-cast aluminum cover equipped with a tamper-resistant screw to keep out unauthorized personnel, a durable hinge which allows the cover to rotate open 180°, two (2) slide egress doors that lock in the open position and auto close around the cables when the covers are closed, an 8° beveled edge that meets ADA guidelines and reduces tripping hazards.
 - .7 cover finishes to be durable brushed aluminum or satin brass plated;
 - .8 include divider to separate services;
 - .9 tunnelling from compartments as required;
 - .10 coordinate dimensions of assembly with thickness of floor/ceiling slab. Exact requirements of devices to be provided as required for specific applications. Confirm type of floor with Consultant prior to ordering and provide coverplate to suit floor type;
 - .11 refer to drawing details and notes for additional device requirements. Provide duplex receptacles to standards as specified in wiring devices article. Coordinate telecommunication jack types and installation requirements with telecommunications structured cabling system contractor responsible for work of structured cabling systems article.

3 EXECUTION

3.01 INSTALLATION OF SWITCHES

- .1 Provide switches and install in electrical outlet boxes. Refer to drawings to determine flush or surface mounting requirements. Generally, flush mount devices in finished areas. Size electrical boxes to suit device requirements as per device manufacturer's recommendations. Properly ground device to box and ground system as per code requirements and manufacturer's instructions.

- .2 For pricing only, switches to be white finishes.
- .3 Where more than one dimmer is shown in the same location, mount dimmers in individual back boxes. Provide matching switches where it is shown adjacent to dimmers
- .4 Ensure that switches located adjacent to doors are located at strike/lock side of door. Confirm door swing requirements on architectural drawings, not on electrical drawings.
- .5 Coordinate installation of door switches with trades responsible for provision of doors and frames. Confirm exact locations of switches with Consultant to ensure optimum operation of switch to door position.
- .6 Except where noted on Interior Design drawings, light switches shall be mounted at height between 900mm (3'-0") and 1,100mm (3'-7") above finished floor.
- .7 All light switches shall be permanently identified indicating the circuit number and source of supply, e.g. "073-ELP-04-02-AF: 2"

3.02 INSTALLATION OF RECEPTACLES

- .1 Provide receptacles and install in electrical outlet boxes. Refer to drawings to determine flush or surface mounting requirements. Generally, flush mount devices in finished areas. Size electrical boxes to suit device requirements as per device manufacturer's recommendations. Properly ground device to box and ground system as per code requirements and manufacturer's instructions.
- .2 For pricing only, receptacles to be ivory.
- .3 Safety shutter type receptacles to be located where shown and required by code.
- .4 Opposing outlets on partition walls shall have a 6" (150 mm) horizontal separation. They shall not be mounted back-to-back.
- .5 Telephone, intercom, etc., wall outlets shall be spaced 4" (100 mm) from power outlets.
- .6 Install USB charger receptacles in extra deep boxes in accordance with manufacturer's recommendations.
- .7 Confirm receptacle finishes via submission to Consultant. Do not order any devices unless final finishes have been approved by Consultant.
- .8 Where receptacles are indicated in counters and benches, box cut-out to be provided in counter and bench. Provide a box, receptacle, plate and branch circuit wiring. Branch circuit wiring within counters and benches to be flexible armoured cable, under requirements of local governing electrical code and standards. Install and connect complete.
- .9 Confirm final receptacle finishes with Consultant as per submission specified in Part 1. Do not order any devices unless final finishes have been approved by Consultant.
- .10 All Receptacle outlets shall be permanently identified indicating the circuit number and source of supply, e.g. "004-NRP-03-02-AG: 23" and "009-NRP-02-02-AA: 5/7".
- .11 Mounting heights, except where noted, shall be as noted on Interior Design drawings.

- .12 Additionally, refer to testing and verification requirements in Section entitled Electrical Work Analysis and Testing and include applicable requirements.

3.03 INSTALLATION OF FACEPLATES

- .1 Provide each switch and receptacle with a faceplate with an opening or openings suitable for device it conceals and covers openings around boxes. Secure faceplates to device frames with screws to match faceplates. Provide larger than standard type faceplates for devices that require engraved nomenclature to define special purpose for that device.
- .2 Provide super stainless steel type 302 faceplates for flush mounted devices.
- .3 Provide galvanized stamped steel faceplates in service areas, equipment rooms and unfinished areas where devices are surface mounted.
- .4 Provide weatherproof insulated faceplates with hinged and gasketed receptacle access flaps for weatherproof receptacles denoted "WP" on drawings.
- .5 Generally, oversized faceplates to be provided where engraved lettering is required.
- .6 Confirm exact material, finish, and colour of faceplates for devices in any particular area with Consultant prior to ordering. Submit sample board as per requirements of Part 1.
- .7 Provide faceplates with printed self-adhesive label on inside face identifying circuit number and panel feeding device. Turn over label maker to Consultant prior to application for Certificate of Substantial Performance of the Work.

3.04 INSTALLATION OF POKE-THRU FLOOR BOX

- .1 Provide required poke through floor fitting assembly in locations required to feed devices in open floor spaces or through which to extend services. Install and mount assemblies through slab in accordance with manufacturer's instructions. Core cut suitable openings to accommodate poke through assembly as per manufacturer's instructions and as coordinated with General Contractor. Coordinate work with trade chasing or cutting floor slab. Provide suitable fire stopping and smoke seal materials around poke through assembly, to maintain fire rating of surface being penetrated.
- .2 Provide service fitting receptacles and outlets as configured in this Specification and/or as shown on drawings. Connect complete. Confirm finishes with Consultant prior to ordering.
- .3 For multiple piece fittings, install floor fitting after any work which may damage fitting.
- .4 Run wiring to floor fittings, in ceiling space of floor below. Coordinate work with trade cutting or pouring floor slab.
- .5 Coordinate mounting requirements for telecommunication type jacks with trade responsible for provision of respective telecommunication systems.
- .6 Ground and bond boxes to local governing electrical code requirements.
- .7 Test assembly to verify proper operation.

END OF SECTION

1 GENERAL

1.01 SUBMITTALS

- .1 Submit shop drawings for products of this Section, and on Schedule of Luminaires on drawings.
- .2 Include photometric data for each luminaire. Include remote LED driver data identifying maximum circuit loading limitations.
- .3 Photometric data to include: total input watts, candlepower summary, candela distribution zonal lumen summary, luminaire efficiency, CIE type, coefficient of utilization, lamp type and lumen rating in accordance with IESNA testing procedures.
- .4 Include copy of certification that lenses and louvers comply with local governing building code requirements for flame spread ratings.

1.02 WARRANTY

- .1 Warranty requirements are as follows:
 - .1 unless otherwise noted, LED and LED drivers for a period of five (5) years from date of acceptance of Work by Owner for its intended use;
 - .2 include costs for personnel, equipment and labour for replacing fixtures, LED boards and/or LED drivers covered under warranty;

1.03 SUBSTITUTIONS

- .1 Provide luminaires as specified in Schedule of Luminaires and as per documented List of Manufacturers, where applicable. During construction period, no substitutions are permitted unless compelling reasons are given and accepted by Owner and Consultant. A delay caused by Contractor's failure to order luminaires to meet construction schedule is not a valid reason.
- .2 Make requests for proposed substitutions as per requirements of Section entitled Electrical Work General Instructions and Division 01.
- .3 Consideration of any proposed substitutions after Bid Period to be at Consultant's sole discretion.

2 PRODUCTS

2.01 LUMINAIRES

- .1 Provide luminaires in accordance with Schedule of Luminaires found on drawings. Luminaires are to be CSA approved or have special local electrical authority approval.
- .2 Some luminaires as noted or directed by Consultant or identified in other Division documents may be supplied by Owner or under another Division of Work. Include in Bid, Work and materials to accommodate such fixtures, including:
 - .1 receiving and inspecting fixtures;

- .2 complete installation;
 - .3 providing basic installation hardware not supplied by luminaire manufacturer;
 - .4 aiming and connecting;
 - .5 providing power feeders and conduit/boxes;
 - .6 cleaning, adjusting and testing;
 - .7 provide required power connections and where luminaires are controlled via remote low voltage controller;
 - .8 include for installation of controller and providing required low voltage wiring in conduit and necessary connections;
 - .9 coordination of exact requirements with supplier of fixtures and Consultant prior to installation.
- .3 Provide thickness of metal as indicated in Schedule of Luminaires and details, or as required so that luminaires are rigid, stable and resists deflection, twisting, warping or bending under normal installation procedures, etc., or no less than requirements specified herein the specifications.
- .4 Unless otherwise noted, construct luminaire bodies from minimum 20 gauge cold rolled prime steel and of rigid construction to permit any suspension method without sag. Unless otherwise noted, provide body finishes of corrosion resistant, chemically treated and electrostatically spray painted baked white enamel. Reflecting surfaces to be white with an average reflectance of not less than 85%. Provide adjustable mounting brackets for troffers mounted in ceilings.
- .5 Unless otherwise noted, linear and continuous linear architectural LED luminaires bodies to be constructed of extruded aluminum and of rigid construction. Unless otherwise noted, provide body finishes of corrosion resistant, chemically treated and electrostatically applied post powder coat finish. Efficiency not to be less than 69%.
- .6 Unless otherwise noted, vandal resistant luminaires to be constructed of heavy duty extruded aluminum rails and die cast end caps, complete with stainless steel torx with centre reject pin and Allen head set screws. Screw heads to be mounted and concealed under lens. Lens to be extruded UV stabilized polycarbonate lens with internal linear ribbed design.
- .7 Provide neoprene or silicone gasketting, barriers and stops where required to prevent light leaks or water/water vapour penetration.
- .8 Fabricate fixtures with a minimum number of joints. Make unexposed joints by acceptable method such as welding, brazing, screwing or bolting. Soldered joints are unacceptable. Do not use blind metal tapping methods or rivets for fastening parts which must be removed during service, or for fastening electrical components and supports. Cast parts, including die-cast members, to be of uniform quality, close grained, rigid, true to pattern, free from blow holes, pores, discoloration, hard spots, shrinkage defects, and cracks or other imperfections that affect strength and appearance or are indicative of inferior metals or alloys.

- .9 Fabricate housings to allow for easy accessibility and replacement of parts.
- .10 Reflectors and reflecting cones or baffles to be free of any tooling marks, spinning lines or marks by other assembly techniques. Finishes to be equal to first quality polished, baffled, and anodized "Alzak".
- .11 Lenses and louvers to comply with local governing building code and other local governing code flame spread rating requirements.
- .12 Unless otherwise noted, construct acrylic lens from 100% virgin acrylic and not less than 3.22 mm (0.125") thick. K12 acrylic lenses to have recessed prismatic pattern with no fade-outs or streaks and be of strain-free and uniform production. Glass lenses to be minimum 9.5 mm (0.375") thick.
- .13 Recessed luminaires with replaceable/serviceable parts such as LED drivers, LED boards /chips, etc., must be accessible from lens side (ie. room side) of fixtures to allow for proper accessibility.
- .14 Luminaires to be factory assembled and tested prior to delivery on site.
- .15 Exposed parts and hardware of luminaires located in non-climate controlled areas to be corrosion resistant and weather resistant. Hardware to be tamper-proof. Manufacturer exterior luminaire poles with corrosion resistant finish and construction. Pole suppliers to ensure that poles supplied are suitable for steady wind velocity and gust velocity of area of installation, and suitable for total effective projected area of lighting equipment. Submit verification of this with shop drawings.
- .16 When requested, submit luminaire samples.
- .17 Dimensions for coves, valances, and strips as shown on drawings are for bidding purposes only. Job measure for exact dimensions of louvers, lenses and strips.
- .18 Dimensions for linear and continuous linear LED as shown on drawings are for bidding purposes only. Job measure for exact dimensions requirements to suit installation location.
- .19 Confirm exact colours and finishes of luminaires with Consultant after award of contract but prior to ordering. Obtain information in time to meet installation schedule.
- .20 Coordinate with dimmer/occupancy control manufacturers to ensure that components are compatible with each other and that interconnections do not affect performance, life or any warranties.
- .21 Acceptable manufacturers / suppliers:
 - .1 GE;
 - .2 OSRAM;
 - .3 Sylvania;
 - .4 Leviton;
 - .5 Cooper Lighting;
 - .6 Omnilumen;
 - .7 BeLuce Canada, Lumacell, or Emergi-Lite for Exit Signs and Battery Units;
 - .8 Approved Equivalent.

2.02 LEDS AND DRIVERS

- .1 General features include:
 - .1 CSA approved, ULC listed and labelled;
 - .2 Operating temperature:
 - .1 Luminaires for applications in climate controlled area: operating temperature range through -20°C (-4°F) to 50°C (122°F);
 - .3 With rapid and changing development of LED technology, provide most technically proven and most advanced and successfully tested LED technology at time of installation;
 - .4 Specification standards to meet requirements of IES LM 79 and LM-80.
 - .5 Be 100% compatible with connected dimmer controls to provide dimming down to 5%.
- .2 Light emitting diodes (LEDs) features to include:
 - .1 LEDs to be selected from same colour bin size for consistency in chromaticity and meet ANSI C78 377A as a minimum;
 - .2 generally, colour temperature range to be from 2700 K to 3500 K; specific temperature requirements to be identified on Schedule of Luminaires;
 - .3 minimum CRI of 85;
 - .4 rated life (based on 70% lumen depreciation level) from 50,000 to 70,000 hours.
- .3 Driver features to include:
 - .1 Operate from 60 Hz input source of 120 VAC with sustained variations of $\pm 10\%$ (voltage and frequency) with no damage to driver;
 - .2 Output regulated to $\pm 5\%$ across load range;
 - .3 Power factor greater than 0.90;
 - .4 Total harmonic distortion less than 20%;
 - .5 Class A sound rating;
 - .6 Comply with ANSI C62.41 Category A for transient protection.
- .4 Where noted, LED drivers shall be Lutron ecosystem drivers to be compatible with quantum lighting control system as specified.
- .5 Acceptable manufacturers to be as recommended by luminaire manufacturers.

3 EXECUTION

3.01 INSTALLATION

- .1 Provide luminaires as required. Obtain required training from manufacturer's representative on any special installation procedures. Install products in accordance with manufacturer's instructions to suit specific installation requirements.
- .2 Before placing luminaire orders:
 - .1 verify quantity requirements;
 - .2 thoroughly review ceiling types, finishes and construction details; verify ceiling types with latest Architectural Drawings; order luminaires to suit correct ceiling type;
 - .3 ensure that required mounting assemblies, frames, rings and similar features are included;
 - .4 confirm colours and finishes with Consultant.
- .3 Include for assembly and mounting of luminaires and LED drivers, complete with:
 - .1 wiring and connections;
 - .2 fittings and hangers;
 - .3 aligners;
 - .4 box covers;
 - .5 other accessories required for a complete, safe and fully operational assembly.
- .4 Where outlet boxes locations are shown on drawings, they are diagrammatic only. Position outlet boxes to coincide with suspension hangers and knockouts.
- .5 Install ceiling fixtures in centre of tiles unless dimensioned otherwise on Reflected Ceiling Plans. Locate hangers on tile centres or intersections. Mount recessed downlights, troffers, and surface mounted luminaires in or on full tiles. Install fixtures in and on acoustical tile ceilings in alignment with tile joints.
- .6 Cut holes for recessed luminaires to exact size so that gaps are not visible or luminaire trims cover gaps.
- .7 Mount surface ceiling luminaires perfectly level or plumb, tightly to ceiling without showing a space or light leak between frame and ceiling.
- .8 Carefully align linear luminaires shown in continuous lines or rows, so that rows appear as straight lines. Variation in alignment not to exceed 6 mm (1/4") for any 5 m (16') run.
- .9 Provide spacers for fixtures mounted on low density ceiling material.
- .10 Protect wiring with tape or tubing at all points where abrasion may occur. Conceal wiring within fixture construction except where design or mounting dictates otherwise.
- .11 Splices:
 - .1 Minimize number of splices.

- .2 Make with approved mechanical insulated steel spring type connectors, suitable for temperature and voltage conditions to which splices are to be subjected.
- .3 Splices are not to be made unless properly terminated in accessible identified junction boxes.
- .12 Support luminaires directly by ceiling slab structure and not to formed steel decking, ceiling hangers, ductwork, piping, cable trays, etc.
- .13 Do not tighten wing nuts, bolts, or screws that allow fixture adjustment for recessed adjustable fixtures.
- .14 Install spread lenses only where called out on Schedule of Luminaires and Specifications.
- .15 Use cloth gloves when handling reflector cones, louvers, glass, sconces and all exposed surfaces of fixtures.
- .16 Co-ordinate luminaire installation with work of other trades to ensure that necessary recessing depths and mounting spaces are provided.
- .17 Install luminaires in accordance with applicable architectural drawing reflected ceiling plans and/or wall elevations and/or field instructions issued by Consultant. Confirm luminaire locations prior to roughing-in. In equipment rooms, shafts and similar secondary areas, install luminaires after mechanical and other major work is roughed in and adjust luminaire locations as required.
- .18 Align and position all adjustable luminaires and ensure that adjustable luminaires are properly positioned as specified.
- .19 Comply with requirements of local governing electrical code regarding support of luminaires in suspended ceilings.
- .20 Independently suspend luminaires in suspended ceilings from ceiling slab. For each luminaire, provide minimum two (2) cable supports secured to ceiling slab and to luminaire. Confirm with local governing authorities and review with Consultant if a variance to this requirement can be made for specific luminaires of low weight.
- .21 Connect luminaires to power circuits and controls as required. Refer to drawings notes and schedules. Include for both normal and emergency power circuits as required.
- .22 Locate exit signs in final locations confirmed with Consultant and approved by local building code authority. Connect to power circuits as required. Where applicable for emergency power requirements, connect to emergency battery units. Relocate exit sign and re-direct direction arrows to suit local building code authority requirements and Consultant's directions.
- .23 Notify Consultant immediately and relocate if necessary as directed by Consultant, if:
 - .1 fixture placement is in conflict with a structural beam, mechanical duct, plumbing pipe, etc.;
 - .2 space above ceiling is not sufficient;

- .3 any reason that a fixture cannot be located where it is dimensioned or shown on construction documents.
- .24 Ground and bond luminaires as per local governing electrical code requirements.
- .25 Existing luminaires designated to be relocated and reused, to be:
 - .1 disconnected, removed and stored in a safe area as designated by Owner until ready for re-installation;
 - .2 inspected, cleaned, repaired and re-lamped with matching/compatible lamps;
 - .3 identified to Consultant of requirement for replacement parts for broken lenses, faulty ballasts, broken mounting hardware, etc., as necessary to return luminaires to good working condition; identify cost to Consultant for repair/replacement parts.
- .26 Prior to turn over of Work to Owner, clean luminaires in manner recommended by manufacturer and to satisfaction of Consultant.
- .27 Additionally, refer to testing and verification requirements in Section entitled Electrical Work Analysis and Testing and include applicable requirements.

END OF SECTION

1 GENERAL

1.1 SUBMITTALS

- .1 Submit shop drawings for products specified in this Section.
- .2 Include data sheets for cabling, faceplates, terminal cabinets, racks, etc., and proposed cabling testing sheets.
- .3 Submit following:
 - .1 Proof that final installation drawings have been reviewed by a Registered Communications Distribution Designer (RCDD);
 - .2 Samples of each type of data/voice jack complete with faceplate;
 - .3 Samples of patch cord;
 - .4 Sample of fibre optic cabling with proposed terminations, and horizontal copper cabling;
 - .5 Sample of proposed labelling of components and wiring;
 - .6 Sample of proposed test sheet;
 - .7 Copy of tester calibration certificate;
 - .8 Written confirmation that telecommunication system vendor is manufacturer's valid certified system vendor for at least duration of contract work and is in good standing at time of Bid submission;
 - .9 Copy of system manufacturer's warranty.

1.2 REFERENCE STANDARDS

- .1 Comply with latest editions of following, as applicable for project:
 - .1 ANSI/TIA-568-D., family of Telecommunications Standards, including:
 - .1 ANSI/TIA-568.0-D - Generic Telecommunications Cabling for Customer Premises;
 - .2 ANSI/TIA-568.1-D - Commercial Building Telecommunications Infrastructure Standard;
 - .3 ANSI/TIA-568.2-D - Balanced Twisted-Pair Telecommunication Cabling and Components Standard;
 - .4 ANSI/TIA-568.3-D - Optical Fiber Cabling Components Standard;
 - .5 ANSI/TIA-568.4-D - Broadband Coaxial Cabling and Components Standard;
 - .6 Issued addendums.
 - .2 ANSI/EIA/TIA 606-C (CSA T528) - Administration Standard for Telecommunications Infrastructure;
 - .3 ANSI/EIA/ TIA-607-D (CSA T527) – Generic Telecommunications Grounding and Bonding (Earthing) for Customer Premises;
 - .4 ANSI/EIA/TIA-569-D (CSA T530) - Telecommunications Pathways and Spaces;
 - .5 ANSI/TIA/EIA-526-7-A - Measurements of Optical Power Loss of Installed Single-mode Fiber Cable Plant;
 - .6 Latest Building Industry Consulting Service International (BICSI) standards;
 - .7 Applicable local Building Codes.

- .2 Work to be installed by system manufacturers certified system installers/vendors who are certified and experienced in implementing selected data cabling system and to perform related testing programs.
- .3 System final installation layout to be designed and/or reviewed by a RCDD. Submit shop drawings verifying this requirement.

1.3 APPLICATION SUPPORT

- .1 Structured cabling system serves as a vehicle for transport of data, video, and voice telephony signals throughout network from designated demarcation points to outlets located at various desk, workstation, and other locations as indicated on drawings and described herein. Applications standards supported include, but be not limited to:
 - .1 IEEE 802.3;
 - .2 10BASE-T;
 - .3 IEEE 802.5;
 - .4 4 Mbps;
 - .5 16Mbps (328 ft [100m], 104 Workstations);
 - .6 TP-PMD.
- .2 In addition, these links/channels to be capable of supporting evolving high-end applications such as:
 - .1 100 Base-T;
 - .2 52/155 Mbps ATM;
 - .3 77 Channel Analogue Broadband Video out to 550 MHz.
- .3 Gigabit cable performance to be capable of supporting existing and evolving applications including:
 - .1 AES/EBU Digital Audio;
 - .2 270 Mbps Digital video;
 - .3 622 Mbps 64-CAP ATM;
 - .4 1000Base-T Gigabit Ethernet;
 - .5 1.2 Gigabit ATM.

1.4 WARRANTY

- .1 System manufacturers to provide a minimum twenty (25) year full parts, labour, and performance warranty on all passive components including structural cabling system. These warranties to be provided in written certificate form and that guarantee following:
 - .1 passive system components, e.g. patch panels, UTP cable and outlet jacks, are free from manufacturing defects in material or workmanship;
 - .2 approved cabling systems exceed specifications of TIA-EIA 568-D standards for specified category, in particular for attenuation and near-end cross-talk, loss and bandwidth requirements;
 - .3 installation supports applications for which it was originally designed as well as future versions of system performance specifications and any future applications using TIA/EIA 568-D component and cabling standards;
 - .4 replacement or repair of any originally installed registered system component to be completed at no cost for parts and labour to Owner during warranty period. Any components repaired or replaced to be warranted for remainder of warranty.

- .2 System manufacturers to provide in writing to Owner that in event of demise or failure or change in approved status of installing certified system installer/vendor, manufacturer to be responsible for providing another certified system installer/vendor to fulfil remainder of warranty conditions.
- .3 Claim for repair procedure to comprise of contractor being notified of a problem and who will conduct necessary tests and repairs to correct problem. Should contractor be unable to resolve problem, contractor to contact system supplier who will take necessary action and provide any technical support to correct problem.
- .4 Initial response time to a repair claim for a registered system to be within four (4) hours from time Contractor was notified of system fault.
- .5 Ensure that selected network cabling component manufacturer includes a system warranty that is a true "end-to-end" structured cabling system warranty from a single manufacturer, which includes data/voice communications outlet and patch cord at workstation, horizontal copper cabling, and patch panel and patch cords at Telecom room. In addition, this warranty is to be valid with selected fibre optic cabling solution.

1.5 SCOPE OF WORK

- .1 This Section provides minimum standards for provision of a structured cabling system to network computer systems for complex. Requirements for network electronics are responsibility of Owner's Network Integrator. Work includes but is not to be limited to following:
 - .1 provision of fibre optic cabling system; provision of fibre optic cabling for risers and intra-building backbone between telecom rooms and for applications as noted on drawings; use of fibre optic backbone cabling to augment system if more than one (1) network switch is used and distance between switches exceeds 90 m (295') and for applications as shown and as required by BICSI standards;
 - .2 provision of category grade rating Category 6A cabling system for a complete networking within complex which can support use of intelligent network switches with Network Management capabilities;
 - .3 organized wiring in a structured cabling system using point to point distribution system incorporating keystone modular terminations;
 - .4 provision of data and voice cabling, data and voice communications outlets, patch panels and associated equipment;
 - .5 system testing and verification;
 - .6 coordination of system requirements and integration requirements with integrated systems.
- .2 The local area network system must be "protocol neutral" and provide users access into a variety of resources from any location within the Complex. An Ethernet backbone shall be utilized for the system with intelligent network switches coordinating and managing data flow. The wiring configuration is based on a "physical star" topology in which cabling runs emanate in a radial pattern from the main data communications room in which the intelligent switches are located.
- .3 Technical features of the structural cabling plan include:
 - .1 use of Category 6A cabling to each data outlet;
 - .2 use of keystone modular Category 6A jacks at workstation ends of data cabling run;
 - .3 backward compatibility to categories 5e, 5 and 3.

- .4 The network cabling system vendor shall coordinate with Electrical Contractor to ensure that properly sized conduits, back boxes outlet boxes, junction boxes and floor boxes are provided of sufficient size as per EIA/TIA Standards to accommodate CAT 6A system wiring and devices, with particular emphasis on bending radii of cabling. Conduit and boxes not meeting Cat 6A standard requirements must be replaced.
- .5 Backbone fibre optic cabling infrastructure to be capable to support 100 Gbps for distances up to 10 km (6.2 mi) for single-mode fibre.
- .6 Connectors for production space and outdoors
 - .1 Provide all terminations within non-office program spaces to the following connector types complete with locking capabilities and dust covers to protect the connectors. This applies to all ELV data systems including but not limited to audio visual and security connections terminated to an outlet. The field terminated male certified link shall be provided by the communications contractor in accordance with section 27 15 00. The contractors AV and security consultants shall provide guidance for these connections to their respective devices if required.
 - .2 All connections shall be supplied with optical CON DUO ARMORED patch cables in appropriate length no less than 15m fitted with NOR-X coloured ring to match chassis connections.
- .7 System to be designed to support minimum 802.11a/b/g/n/ac standards.

1.6 SYSTEM SUPPLIER QUALIFICATIONS

- .1 System supplier qualifications include:
 - .1 being an established communications and electronics contractor that has and currently maintains a locally run and operated business for at least five years and holds applicable provincial and local licenses;
 - .2 be an Authorized Distributor or established franchisee for manufacturer of product/system proposed with full manufacturer's warranty privileges and be capable of providing post warranty service;
 - .3 employ technicians who have attended and successfully completed manufacturer's technical certification classes for proposed system;
 - .4 show satisfactory evidence, upon request, that they maintain a fully equipped service organization capable of furnishing adequate inspection and service to system on a 24-hour/7-day basis;
 - .5 maintain at their facility necessary spare parts in proper proportion as recommended by manufacturer to maintain and service equipment being supplied.
- .2 Submit written evidence of qualifications to Consultant for approval.

2 Products

2.1 FIBRE OPTIC CABLE AND TERMINATION EQUIPMENT

- .1 Various fibre optic cabling types and number of strands are required for network cabling infrastructures supporting various systems and equipment. Refer to drawings and specifications for additional requirements and confirm exact requirements with successful system vendors and Consultant prior to start of work.

- .2 Intrabuilding (within buildings): single-mode OS2 graded-index fibre optic cabling with following specification:
 - .1 ULC listed, OFNR/CMR riser rated, tight buffered;
 - .2 multi-strand single-mode laser optimized fibre optic cabling; (refer to drawings for number of strands);
 - .3 single-mode fibre to be 8/125 µm (900 µm).
- .3 Interbuilding (between buildings): single-mode fibre optic with following specifications:
 - .1 ULC listed for outdoor application;
 - .2 loose tube;
 - .3 3 mm gel filled buffer tubes, stranded around a central strength member and overall polyethylene outer jacket;
 - .4 multi strand – refer to drawing for number of strands.
- .4 Provide flexible PVC inner duct for installation in conduit, between cabinets within telecommunication space or cable run within large conduit which might contain any other cable for fibre optic cabling installations.
- .5 Provide plenum CMP rated cabling for applications as required by local authorities and codes.
- .6 Provide rack mount fibre optic termination patch panel in each telecommunication room/closet. Provide panel loaded with adapter strips to suit rack space, quality of fibre strands being terminated, and allowing for a quantity of 30% additional spare adapters. Include for required accessories, such as cable entry brackets, offset bracket kits, front cover, and standard supplied accessories. Provide panel and accessories in black colour finish. Mount in racks in accordance with manufacturer's instructions.
- .7 Fibre optic patch cords to be factory terminated with fibre connectors (exact type to be confirmed prior to start of work with Consultant/Owner) and of length to suit application. Colour requirements to be reviewed with Consultant/Owner prior to ordering.
- .8 Fibre optic cabling and component terminations to be type LC which must be confirmed with Owner and/or Consultant prior to start of work.
- .9 Acceptable fibre optic cabling infrastructure manufacturers are:
 - .1 Leviton
 - .2 Belden;
 - .3 Commscope;
 - .4 Corning;
- .10 Tracer wire to be CSA approved/ULC listed and labelled, high-strength copper-clad steel conductor insulated with high-density, high molecular weight polyethylene (HDPE) insulation, and rated for direct burial use. Conductor to be minimum 20% conductivity for locating purposes. Insulation colour to meet local industry colour code standard for identification of buried utilities. Install in duct with fibre optic cabling as per manufacturer's instructions.

2.2 HORIZONTAL CABLING

- .1 Horizontal cabling to data/voice outlets to be ULC listed and labelled, UTP cable and to comply with TIA/EIA-568 requirements for Category 6A transmission, ETL tested and verified to exceed Category 6A component performance. Cable minimum specifications to be:
 - .1 conductors: 23 AWG. copper conductor in twisted with four pairs contained in a flame retardant PVC jacket separated by a divider;
 - .2 cable grade: Category 6A;
 - .3 overall sheath: riser rated CMR / plenum rated CMP; blue outer sheath;
 - .4 PVC outer jacket colour to be of different colours to distinguish different systems as per Owner's direction; confirm colours with Consultant prior to Ordering.
- .2 CAT 6A system to exceed ANSI/EIA/TIA 568.2-D standard for an enhanced CAT 6A 4-conductor channel. Demonstrate that proposed manufacturer's solution is guaranteed to exceed CAT 6A requirements across entire swept frequency range of 1–500 MHz. Submit with shop drawings, ETL test reports to verify full channel performance of above specified measurements.
- .3 Provide plenum CMP rated cabling for applications as required by local authorities and codes.
- .4 Incoming copper cabling to be provided with suitable lightning protection devices. Refer to additional requirements later in this Section.
- .5 Cable colours to be different to distinguish different systems as per Owner's requirements. Confirm exact colour finishes and T568 pinning arrangement with Consultant prior to ordering. Provide as follows:
 - .1 Data (blue)
 - .2 WAP (orange)
 - .3 AV (yellow)
 - .4 BAS (green)
 - .5 Security (red)

2.3 OUTLETS

- .1 Data outlets to meet or exceed category 6A performance and meets following specifications:
 - .1 flush wall mounting faceplate to fit on single gang recessed outlet box, complete with device bracket or provisions that hold jacks securely in place;
 - .2 configuration: Category 6A, eight-position, RJ-45 keystone modular jacks, T568B pinned; confirm exact requirements with Owner prior to ordering;
 - .3 constructed of high impact, flame retardant, thermoplastic;
 - .4 copper wires and connectors;
 - .5 faceplates: moulded PVC, finish to Consultant's direction, mounted to outlet box and bracket with matching screws;
 - .6 icons with suitable data and voice identifications.
- .2 Wall mounted telephone outlets to include features as follows:
 - .1 required Category A rating keystone modular jack;
 - .2 wall plate of stainless steel construction;
 - .3 mounting studs on plate which are positioned to mount standard wall mount telephones with keystone adaptation flush to wall surface;

- .4 accept wall mountable phones with short patch cord connections to jack module.
- .3 Jacks colours and faceplate colours to be different to distinguish different systems as per Owner's requirements. Confirm exact colour finishes and T568 pinning arrangement with Consultant prior to ordering. Provide as follows:
 - .1 DATA (Blue)
 - .2 WAP (orange)
 - .3 AV (Yellow)
 - .4 BAS (green)
 - .5 Security (red)
- .4 Quantity of jacks and configuration of faceplates are as detailed on drawings.
- .5 Provide snap-in plastic dust covers on blank outlets and unused outlets.

2.4 PATCHPANELS

- .1 Modular patch panels with features as follows:
 - .1 Cat 6A certified, 110 IDC technology;
 - .2 Cat 6A Angled modular Patch Panel 48 port, 2U
 - .3 rack mounting hardware for patch panels to be rack mounted;
 - .4 wall mounting brackets and hardware for wall mounted units;
 - .5 24 port and 48 port RJ45 jacks, as required;
 - .6 circuit identification designation strip, snaps onto wiring block;
 - .7 horizontal trough for cables;
 - .8 distribution rings and ancillary devices as required.
- .2 Each jack connector module to have a T568B eight pin RJ 45 jack on front and 110 connectors on back. Panels to mount onto standard EIA 19 inch racks or cabinets and have capability to be stacked in larger systems. Horizontal data and voice cabling for various telecom rooms to terminate onto patch panels provided into floor standing or wall mounting equipment enclosures, as detailed and as required.
- .3 Patch panel system to include required accessories such as bezels, harnesses, pigtails, connectors, jumpers, and retaining rings, interlay racking panels, horizontal wire managers etc., to provide for patch cord management.
- .4 A wall mounted NEMA 2 enclosure with removable covers to be provided on wall near fibre patch panel and innerduct to be provided for fibre cabling extending from this enclosure to fibre patch panel. This slack enclosure to be sized to accommodate a length of approximately 20 m (60') of slack at each end of runs. Ensure that fibreglass centre member is secured to enclosure's designed anchor points according to products design.

2.5 PATCH CORDS AND CABLES

- .1 Copper data patch cords to be modular, 24 AWG stranded copper, Category 6A, ISDN wired.
- .2 Copper patch cords to be factory terminated and tested, and be provided in lengths from 600-2100 mm (2'-7') at patch panel end to suit specific applications. Lengths to meet manufacturer's requirements to comply with required category grade performance standards. Provide patch cords in quantities to accommodate requirement that all ports are active.

- .3 For Simulation Lab stations consider the patch cable length as the adjustable display's highest position.
- .4 Fibre optic patch cords to match and be of same manufacturer as fibre optic cabling and be with required terminations. Patch cords to be provided to suit end to end structured cabling system and to accommodate network electronics as directed by Consultant and Owner. Connector terminations to be LC type, confirm with Consultant and Owner prior to ordering.
- .5 Patch cords to be of different colours to distinguish different systems as per Owner's requirements. Confirm exact colour finishes with Consultant prior to ordering.
- .6 Patch cords for Wireless access points to be 3' long and color white.

2.6 EQUIPMENT RACKS

- .1 Equipment Racks shall be Four Post Racks.
 - .1 Racks to be nineteen-inch (19") 44RU rack securely bolted to the floor.
 - .2 Each rack shall be provisioned with vertical and horizontal cable management as per drawings.
 - .3 Rack mounted multi- outlet power strips with surge protection, integral breaker, pilot light and power cord with twist lock type plug and receptacle provisions; number of outlets to be same as number of active devices housed in the rack.
 - .4 Required mounting hardware, label kits, Velcro style fasteners and ancillary devices.
- .2 Include grounding provisions for each rack, to meet previously listed standards, which include but are not limited to following provisions:
 - .1 copper ground strip mounted on side rail extending full height of rack;
 - .2 equipment jumper kits, to bond network equipment to rack ground strip;
 - .3 common bonding network to rack jumper kit, to bond rack to room common bonding network;
 - .4 hardware including, copper compression HTAPS, paint piercing washer kits, bonding screws and electrostatic discharge port kits.
- .3 Acceptable manufacturers are:
 - .1 listed network cabling system manufacturers;
 - .2 Legrand;
 - .3 CPI;
 - .4 Middle Atlantic

2.7 RACK MOUNT SINGLE PHASE UPS UNIT

- .1 Provide rack mount uninterruptible power supply (UPS) units for various communication systems, as specifically identified on drawings.
- .2 UPS units specified herein provides a basis for quality and performance. Units provide an uninterruptible clean power source for main system control units in event of brown outs or surges/spikes to normal power source and provide power during period between loss of normal power and transfer to emergency power.

- .3 CSA approved and ULC listed, continuous duty, on-line uninterruptible power supplies, as specified in following paragraphs and as detailed on drawings, and with following features.
 - .1 static inverter;
 - .2 rectifier/charger;
 - .3 automatic by-pass;
 - .4 LCD display;
 - .5 monitoring and control components;
 - .6 microprocessor controlled logic;
 - .7 surge, spike and continuous brownout protection;
 - .8 integral hot swappable battery pack;
 - .9 advanced battery management technology;
 - .10 communication interface and relay cards;
 - .11 cabinet enclosures;
 - .12 required ancillary devices.
- .4 Front panel display consists of a LCD screen display for system status and functions. LED indicators indicate system status including Standby, Normal, On Bypass, and On Battery. Push Buttons are included for ON/OFF and TEST/ALARM RESET.
- .5 System software provides control, monitoring and communication requirements of UPS unit and batteries. System software to be compatible for use by a wide range of operating systems.
- .6 Performance ratings are as follows:
 - .1 output power – as detailed on drawings;
 - .2 input voltage & output voltage – as detailed on drawings;
 - .3 input power factor – 0.95 lag minimum;
 - .4 output voltage regulation – +/-3% from nominal output voltage for any steady state operating condition;
 - .5 output voltage THD – 5% maximum typical;
 - .6 operating temperature – 5°C to +40°C without derating;
 - .7 storage temperature – 0°C to 40°C;
 - .8 relative humidity – 95%;
 - .9 altitude – 1500 m (5,000') without derating;
 - .10 audible noise – less than 50 dBA (at 1 m [3']) from any operator surface
- .7 Additional Requirements:
 - .1 Connections – 1.8 m (6') AC input line cord and 5-15R and 5-20R output twist-lock type receptacles as required;
 - .2 Battery pack – standard internal, factory preassembled and prewired, sealed, maintenance-free, lead acid type batteries to provide minimum 12 minutes of run time for full capacity rated load of UPS to meet respective system requirements.
 - .3 Communications interface – communications interface and relay cards for integration to various systems, allowing for monitoring by respective system control panels; include interface with BMS;
 - .4 Enclosure – provide entire UPS unit including batteries and options within enamelled painted steel enclosures; enclosures to be suitably ventilated;

- .5 Warranty – 1 year full parts and labour warranty including 24 hours around clock maintenance and service of complete system;
- .6 Testing and Verification: Test units and verify performance on site. Prepare and sign verification report letter that states system has passed manufacturer's testing and performs to manufacturer's requirements for application.

2.8 LIGHTNING PROTECTION

- .1 Provide protection of communication lines, as recommended by referenced codes and standards including UL-497. Products to be equivalent to Tii series 606 "Protector Pack" blocks. exact type of product to be confirmed with product manufacturer to accommodate number of incoming pairs and type of conductors. Generally, base design requirements on following:
 - .1 for data communications: required category grade rating rated protector blocks with protection modules of ultra-low capacitance solid state technology to protect frequencies up to 250 MHz; blocks to include required solid state modules to suit conductor pair counts, mounting bracket and cover;
 - .2 protection requirements at service entrance to also be confirmed with service provider;
 - .3 protection blocks to be provided with mounting provisions to suit design application, i.e. wall mounting at conductor building entrance or rack mounting.
- .2 Contact manufacturer and review system requirements to determine exact product requirements for lightning protection. Ensure that main incoming lines and both ends of lines running between buildings are provided with adequate lightning protection to recommendations of system manufacturer.
- .3 Install devices in accordance with device manufacturer's instructions.

2.9 ACCEPTABLE NETWORK CABLING SYSTEM MANUFACTURERS

- .1 Horizontal network copper cabling infrastructure is to be end-to-end solution from a single manufacturer, which includes data communication outlets and patch cords at workstations, and patch panels and patch cords at Telecommunication rooms. To this horizontal network is integrated fibre optic cabling infrastructure from same manufacturer or approved listed herein, maintaining full warranty requirements for systems comprising this Section.
- .2 Acceptable network cabling system manufactures for provision of horizontal network copper cabling infrastructure are:
 - .1 Belden;
 - .2 CommScope;
 - .3 Panduit;

2.10 ACCEPTABLE CONTRACTORS

- .1 Contractor selected for installation of structured cabling system to provide confirmation of following:
 - .1 detailed knowledge and experience in fibre optic cabling and category grade rating copper UTP wiring installations;
 - .2 detailed knowledge and experience in installation of Intelligent equipment;

- .3 experience in troubleshooting and problem solving in data communication networks.
 - .4 ability to provide system manufacturer's certified warranties;
 - .5 certified and valid proof of being system manufacturer's authorized vendor.
- .2 Refer also to supplier requirements specified in Part 1.

3 Execution

3.1 INSTALLATION OF NETWORK CABLING – GENERAL

- .1 Properly handle and install structured network cabling in accordance with manufacturer's specifications. Avoid undue pulling tension, abrasion, or rough handling to ensure that cables will permit transmission up to required category rating design speed for cables.
- .2 Install cables without splices or cuts to ensure elimination of reflections, discontinuities, impedance mismatches, etc. maximum horizontal length of copper cabling from workstation to network switch is not to exceed 90 m (295') or less if recommended by system manufacturer to meet required category grade rating performance standards. Maximum length of patch cables (either cross connects or interconnecting with electronic equipment to connect devices at work area outlet), to be a total of 10 m (30'). Maintain system manufacturer's minimum channel lengths as confirmed with system manufacturer. Provide cable loops in accordance with manufacturer's instructions.
- .3 Unless otherwise noted or where cable tray is shown for such use, run cabling in conduit. Install pull cords for future use, in conduits extending between floors.
- .4 Generally, no more than two (2) 90-degree changes in direction are recommended for cable installed in conduit without pullboxes and not more than 40% fill ratio. Confirm exact conduit bending radii restrictions and fill ratios with system manufacturer and comply with those standards.
- .5 With consideration in minimizing alien crosstalk to levels as per BICSI standards and manufacturer's standards, dress cables in a neat and orderly fashion from entrance of communications closet to relay racks using vertical and horizontal cable management trays and paths. Do not exceed manufacturer's distance limitations to maintain required category rating performance standards.
- .6 Care to be taken to ensure that during installation, nicks, abrasions, burning and scuffing of cable is prevented. Replace cables found to be damaged regardless of whether cable passes category grade rating or fibre performance testing standards.
- .7 Secure bundled cables transitioning between floors via ladder cable tray, to vertical ladder sections with Velcro wraps. Use waterfall (rounded transition) fittings for cable changing from a horizontal path to a vertical one. This is to maintain minimum bend radius for cabling system. Support cables running through risers between floors such that they are properly supported for their weight, especially in situations with high pair count cables and large bundles.
- .8 Electrical Contractor and telecommunication system vendor to provide coordination of structured cabling system with other systems as required.

- .9 Required necessary drilling and anchoring components to be installed before any horizontal cable is installed.
- .10 Route horizontal cable into equipment racks/enclosures and neatly bundle with Velcro cable ties. Maximum number of cables per bundle to be 25.
- .11 Securely mount fire retardant plywood on wall in each telecommunications room or closet.
- .12 Review installation of conduits and boxes and advise Electrical Contractor where products do not comply with CAT 6A Standards. Ensure that products are replaced as required to meet standards.
- .13 Cables wraps are to be Velcro type and are not to be over tightened.
- .14 Provide grounding and bonding requirements as specified in Section entitled Grounding and Bonding.

3.2 INSTALLATION OF FIBRE OPTIC CABLE

- .1 Provide fibre optic cable and inner duct for running in conduit between main/secondary equipment room and each telecom room, as well as between buildings. Install in strict accordance with manufacturer's specifications. Refer to riser drawing for run requirements.
- .2 Comply with manufacturer's minimum installation bend radius. Allow slack at sharp turns in cable run and immobilize cable at point of bend. Monitor tension on cable during installation when pulling winches are used and do not exceed tensile rating of cable. After installation, only allowable tensile force on cable to be that of its own weight. Terminate onto equipment terminations in accordance with manufacturer's instructions.
- .3 Attachments and grips for cable and installation temperature requirements to be provided as specified by manufacturer.
- .4 Terminate cable, install termination shelf panel on rack and splice/breakout fibres as required in accordance with manufacturer's recommendations to suit Owner's directions. Provide patch cords as required.

3.3 INSTALLATION OF PATCH PANELS AND ACCESSORIES

- .1 Provide patch panels onto racks in locations. Provide terminating hardware and connectors to suit incoming and outgoing cabling. Clearly identify each port. Provide patch cords as required. Install devices in accordance with system manufacturer's requirements.
- .2 Terminate both data and voice horizontal cabling onto patch panel punch downs using manufacturer's recommended tools. Bundle cabling in neat configuration and secure to patch panels and rack assemblies. Typically dedicated separate patch panels are required for data and voice.
- .3 Install rack enclosures on walls. Neatly bundle wiring within wiring management channels. Do not over tighten Velcro straps. Ground racks as required.

3.4 INSTALLATION OF TERMINATION HARDWARE

- .1 Provide 110 connectors and mounts on hardwood backboards on walls or on racks as per drawing details. Properly punch down cabling with manufacturer's required tool and label each connector as required.

- .2 Run interconnect cables neatly secured and bundled across connectors and between banks of mounts. Use D-rings to their full advantage. Neatly bundle pigtails and secure to 110 connectors.
- .3 Where wall mounted, align mounts in straight formations to provide a neat installation and to minimize interconnect wiring lengths.
- .4 Co-ordinate with Owner's network integrator to determine exact requirements for telephone service interconnections.

3.5 COPPER CABLE INSTALLATION

- .1 Run horizontal, UTP cables continuous from end to end with no splices.
- .2 Install horizontal cables in Star topology, emanating from rack mounted patch panel(s) and terminating on data outlet faceplates in rooms or other workstation locations. maximum length for horizontal cables to not exceed 90m (295'). Maximum length for patch cords at patch panel to not exceed 3m (10').
- .3 Install conductors in cable tray and conduit runs designated for data and voice conductors. Do not fasten conductors and conduit to suspended ceiling support systems. Support conduit to building structure slab independent of other support.
- .4 Terminations to involve as little outer jacket removal as possible and cable pairs "untwisting" is to not exceed 6 mm (¼").
- .5 Provide slack cable to allow for minor workstation relocations. Provide a coil of slack cable of an approximate 2 m (6') length for each workstation outlet run.
- .6 For main voice backbone cabling from main telecom room, provide 110 connectors and mounts on hardwood backboards on walls, as required. Design system layout to best suit incoming and outgoing cables. Properly punch down cabling with manufacturer's required tool and label each connector as required.
- .7 Run interconnect cables neatly secured and bundled across connectors and between banks of mounts. Use D-rings to their full advantage. Neatly bundle pigtails and secure to BIX/110 connectors.
- .8 Align mounts in straight formations to provide a neat installation and to minimize interconnect wiring lengths.
- .9 Coordinate with Owner's network integrator to determine exact requirements for telephone service interconnections.
- .10 Provide jumpers/pigtails to interconnect backbone wiring to rack mounted voice patch panels where horizontal voice cabling is terminated.
- .11 For horizontal copper backbone cabling, multi- pair conductor cabling is preferred. If available only in limited number of pair cabling, provide multiple runs to provide quantity as identified on drawings, and increase conduit diameters to suit exact number requirements, in accordance with of standards and codes.

3.6 PENETRATION THROUGH FIREWALLS

- .1 Provide a conduit sleeve where horizontal cables penetrate firewalls. Size conduit sleeve at 40% fill ratio with a plastic bushing at both ends.
- .2 After conduit sleeve is installed, fill opening around conduit with firestop and smoke seal materials.

3.7 INSTALLATION OF OUTLETS

- .1 Connect each data/voice outlet with a 4-pair, UTP cable. Test and identify each outlet and faceplate. Wire and connect data/voice jacks back to respective dedicated racks in telecom rooms. As detailed, extend voice cabling from voice patch panels to wall mounted 110 connectors, using patch cords, cross connects/jumpers, etc. as required.
- .2 Provide outlet jack/faceplate configuration as detailed on drawings.
- .3 Drawings identify data jacks for wireless access point receivers (antennae). These locations are approximate. Confirm exact locations during onsite radio frequency studies. Allow for jacks to be repositioned up to 4m (15') to suit results of studies. Perform studies after completion of construction of interior structures. If studies are not performed at discretion of Owner, obtain direction from Consultant to leave slack coiled length of cable on each run, allowing for repositioning.

3.8 SEPARATION OF DATA COMMUNICATION CABLES FROM SOURCES OF ELECTRO-MAGNETIC INTERFERENCE

- .1 Separate data communication cables from sources of electromagnetic radiation in accordance with TIA Standard Proposal SP-2072 and following:
 - .1 FT-6 rated data cabling raceway and power conductors (2 KVA power circuits) raceway require 125 mm (5") clearance;
 - .2 for fluorescent luminaires, required clearance is 300 mm (12");
 - .3 clearance increases up to 600 mm (24") for power circuits over 5 KVA.
 - .4 for large motor, transformers, power panels, etc., required clearance is 1m (39");
 - .5 route cables to avoid direct contact with steam piping, hot water piping or other heat sources to avoid thermal degradation.

3.9 INSTALLATION OF RACKS

- .1 Provide racks and secure to floor with bolts and concrete anchors.
- .2 In locations where more than one rack is required, butt multiple racks together. Provide wiring channel interconnection such that wiring from rack to another is not exposed.
- .3 For open racks, provide metal raceway chimney channel for conductors extending down from ceiling, such that wiring is not exposed. Secure channel to rack and ceiling.
- .4 Run wiring neatly bundled within wiring management channels. Do not over tighten Velcro tie wraps such that they deform cable jacket. Velcro straps to easily slide along length of cable. Velcro tie wraps used in plenum spaces to be CMP/FT-6 rated.
- .5 Protect cable from any obstructions using appropriate grommeting in roof of rack.
- .6 Properly ground and bond rack and equipment to room ground bus as per specifications and to standards of TIA/EIA 607.

3.10 INSTALLATION OF RACK MOUNT UPS

- .1 Electrical contractor to provide rack mount single-phase UPS units as specified and secure to rack with screws.
- .2 Install units in accordance with manufacturer's instructions to suit specific installation requirements.
- .3 Plug units into adjacent receptacles fed from non-life safety emergency power circuits. Test and commission equipment and document testing in test report.

3.11 INSTALLATION OF WAP (WIRELESS ACCESS POINT)

- .1 Run two Cat.6A cables to each WAP (Wireless Access Point) position to the corresponding LAN Room, ensuring that the total permissible wire length of 90 m is not exceeded.
- .2 Terminate all cables with 8-position, Cat.6A rated, modular jacks at both ends; jacks to be colored white at the WAP end and orange at the IT closet end. At the LAN Room the cables shall be terminated in rack mounted, black colored patch panels and at the WAP end the cables shall be terminated in the electrical boxes equipped with modular cream colored faceplates.
- .3 The majority of WAPs shall use ceiling-mount style and be positioned below the ceiling.
- .4 dn-207-sw, dn-217, dn-226b are smaller, hospitality-style access points which are to be installed on the mall around 6-7 feet from the floor in the position indicated. Each WAP shall be mounted on a single-gang electrical box. Typically the cabling is routed inside of the electrical box aesthetically.
- .5 The WAPs shall be provided by U of T I&ITS and be picked up by contractor. Two-week notice is required before picking up the WAPs. WAPs are available for pick up from University of Toronto I+TS, 4 Bancroft Ave., Room 103.
- .6 Supply and install white colored, 2' length, Cat.6A rated, 28 AWG, patch cables between the WAP and the data outlet.
- .7 Supply orange colored, 1' length, Cat.6A rated, 28 AWG patch cables for each WAP to be installed by U of T ITS at the LAN Room.
- .8 Labeling schema:

W-room#-{direction}-cable#, or w-floor#/room#-{serial}-

cable# Notation:

- I. {direction} means one of {n, s, e, w, ne, nw, se, sw} for a choice of 8 items.
- II. {serial} means one of {a-z} for a choice of 24 items.
- III. The per WAP cable numbers shall be a choice of {1, 2}

For example:

label "w-302-ne-1" means the cable is for the WAP located at north-east of room 302, last digit "1" represents this cable is #1 cable.

Labeling schema			
floor	AP name	Label 1	Label 2
1 st	dn-134k	w-134k-1	w-134k-2
Mezzanine	dn-m200	w-m200-1	w-m200-2
2 nd	dn-207-e	w-207-e-1	w-207-e-2
2 nd	dn-207-n	w-207-n-1	w-207-n-2
2 nd	dn-207-ne	w-207-ne-1	w-207-ne-2
2 nd	dn-207-nw	w-207-nw-1	w-207-nw-2
2 nd	dn-207-se	w-207-se-1	w-207-se-2
2 nd	dn-207-sw	w-207-sw-1	w-207-sw-2
2 nd	dn-207-w	w-207-w-1	w-207-w-2
2 nd	dn-217	w-217-1	w-217-2
2 nd	dn-219b	w-219b-1	w-219b-2
2 nd	dn-226b	w-226b-1	w-226b-2
2 nd	dn-227	w-227-1	w-227-2

- .9 Test cables as required by standards and supply test result to the PM.
- .10 Clean and dispose of all job related refuse.
- .11 Supply cable test results, “as-built” documentation, and 25-year manufacturer’s warranty for installations as specified by current University of Toronto.
- .12 Cabling should be installed with care to avoid room obstructions (furniture, infrastructure, etc.)

3.12 SYSTEM IDENTIFICATION

- .1 Provide a complete identification system that clearly designates following:
 - .1 horizontal cable;
 - .2 workstation (or faceplate);
 - .3 horizontal/passive patch panel port;
 - .4 switch/active patch panel port;
 - .5 patch cords;
 - .6 switch rack.
- .2 Obtain Owner’s approval of identification format, prior to start of work. Format to comply with Owner’s standards. Submit proposed identification system and nomenclature with shop drawing submission.
- .3 Labels:
 - .1 Labels for outlet and patch panel identification to be typewritten/computer printed self-adhesive type with white printing area at outlet location and on face of patch panel; legible permanent marker on inside of outlet box cover; use minimum font size Arial 10 point.

- .2 Number and identify each computer hub rack with a 20 mm x 50mm ($\frac{3}{4}$ " x 2") engraved lamacoid plate, with white letters on black background. For letters and numbers use Arial 24 font size. Fasten nameplates with minimum two metal screws.
- .3 Cable Identification:
 - .1 Permanently identify horizontal UTP cables at both ends of cable, placed within 13mm ($\frac{1}{2}$ ") at outlet location and 50 mm (2") at rack location and inside of outlet cover in following manner:
"CABLE # / RACK # / PATCH PANEL PORT # / OUTLET #"
- .4 Faceplate:
 - .1 Label data ports: "Closet / Patch Panel/Port Number", where closets to be numerically assigned, patch panels to be sequentially alphabetically assigned beginning at top of rack and ports sequentially numerically assigned related to number of ports per patch panel.
 - .2 Label voice ports: "Port Number/Level/Closet", where ports are sequentially numerically assigned, level refers to floor level on which communication closet is located and closets to be numerically assigned as per data ports.
- .5 Patch panel And Patch Cord Identification:
 - .1 Identify patch panel ports in simple numeric form approved by Consultant/Owner.
 - .2 Identify patch cords at both ends in simple numeric form, not necessarily corresponding to port numbers and be approved by Consultant/ Owner.
- .4 Identification Log:
 - .1 Record cable and workstation identification in a hard copy "CABLE IDENTIFICATION LOG" which is to be handed over to Owner after cable testing and certification is complete. Forward duplicate copy to Consultant.

3.13 CABLE TESTING AND SYSTEM CERTIFICATION

- .1 Structured cabling system certification to include 100% cable testing and verification for an EIA/TIA required category grade rating solution.
- .2 Perform verification of each cable and document on a cable testing sheet forming part of hard and soft copy documentation supplied at end of installation. Testing sheets to list detailed performance test measurements as requested and as required to prove compliance with referenced standards. Also include summary sheet of passes, failures and rectified failures. Submit sample of test sheet with shop drawings.
- .3 Comply with system manufacturer's testing and certification procedures.
- .4 Testing Procedures:
 - .1 Perform testing using Category 6A testers such as Fluke Networks Versiv family, or equivalent Microtest or Scope Communications. Tester to meet TIA/ISO certification standards for Levels IIe, III, IIIe, IV and V. Submit with shop drawings copy of calibration certificate issued by tester manufacturer's authorized technician identifying calibration within one year of use for testing on this project. Testing to include, but not be limited to following:
 - .1 wire map;
 - .2 cable length;

- .3 attenuation;
 - .4 near end crosstalk (next);
 - .5 power sum near end crosstalk (PSNEXT);
 - .6 equal level far end crosstalk (ELFEXT);
 - .7 power sum equal level far end crosstalk (PSELFEXT);
 - .8 return loss;
 - .9 ACR;
 - .10 power sum ACR;
 - .11 end to end continuity;
 - .12 opens or shorts;
 - .13 pair polarity.
- .2 Field testing units for single mode fibre optic cabling to comply with ANSI/TIA/EIA-526-7.
 - .3 Tester to include required modules for certification testing of fibre optic cabling. Perform fibre testing on each fibre in completed end-to-end system. Do not splice cables except where approved by Consultant. Testing to consist of an end-to-end power meter test performed per TIA/EIA-455-53A and. Provide system loss measurements at 1310 and/or 1550 nanometers for single mode fibres. These tests also include continuity checking of each fibre.
 - .4 Test backbone 1310 and 1550 nm for single mode in at least one direction.
 - .5 Conduct test set-up and performance in accordance with ANSI/TIA/EIA-526-7 and/or ANSI/TIA/EIA-526-14 Standards, and to manufacturer's application guides.
 - .6 Perform attenuation testing with a stable launch condition using two-meter jumpers to attach test equipment to cable plant. Light source to be left in place after calibration and power meter moved to far end to take measurements.
 - .7 Replace cable not passing testing procedure, in its entirety. No splicing is permitted in repair of any defective cable.
- .5 Reports:
 - .1 Submit test results to system manufacturer and obtain manufacturer's certificate of approval of system. Submit detailed indexed test report in a 3 - ring binder with manufacturer's certificate of approval and covering letter from company responsible for installation and testing of system stating accuracy of report. Letter to be signed by company's authorized testing technician. Document testing and reports with date and time of testing, testing technician's name and signature and specification Section number that test fulfilled.
 - .2 Submit copy of report including test reports in digital format loaded on USB type memory flash drive.

3.14 SYSTEM TRAINING AND INSTRUCTIONS

- .1 Provide training of Owner's designated staff on principles of connections and operations to system. Clearly instruct on procedures of disconnections and reconnections to accommodate changes and relocations of connected equipment.

END OF SECTION

PART 1 – GENERAL

1.1 Reference

- .1 Section 26 00 10 applies to and is a part of this Section of the Specification.
- .2 Section 26 05 00 forms a part of this Section and contains requirements, products and methods for execution that apply to this Section.

1.2 Shop Drawings

- .1 Submit shop drawings for IP Ceiling / Wall Speaker specified in this Section for Voice Paging – PoE and compatible with existing Dentistry overhead paging systems.
- .2 Do not order the speakers until the shop drawings are approved by the U of T I&ITS and the consultants.

1.3 Scope of Works

- .1 Contractor shall supply and install IP Ceiling / Wall Speaker specified in this Section. New speakers will be connected to existing Dentistry overhead paging systems through structured cabling system & the Dentistry data network switches.
- .2 Existing Headend equipment is located in the Dentistry data center 413. U of T I&ITS team is responsible for any additional headend / active equipment if required, and is also responsible for the system re-commissioning to accommodate new speakers.

PART 2 – PRODUCTS

2.1 IP Ceiling Speakers

- .1 Digital PoE IP Ceiling Speakers shall be supplied, installed and connected by the Contractor.
Manufacturer: Algo Communication Products Ltd.
Model: 8188
Link: <https://www.algosolutions.com/product/8188-ip-ceiling-speaker/>
- .2 The 8188 IP Ceiling Speaker is a SIP speaker used in a drop ceiling for voice paging, emergency, and playing music. The speaker is a fully compliant 3rd party SIP endpoint. As a result, this IP ceiling speaker is compatible with most hosted / cloud and premise-based VoIP telephone systems.
- .3 An embedded microphone allows the 8188 to monitor ambient noise where volume is automatically adjusted according to background noise levels for paging and alerting. The microphone may also be used for two-way talkback.
- .4 The 8188 contains 1 GB internal memory and is pre-loaded with several commonly used audio files for ring sounds. Users may also record or upload custom audio files, such as music, sound effects, or voice announcements.
- .5 Speakers Features
 - .1 Wideband HD audio (G.722 voice codec) for high intelligibility speech
 - .2 Secure SIP using TLS and SRTP

- .3 Configurable via user-friendly web interface or auto-provisioning
- .4 Ambient noise response to automatically adjust audio output level
- .5 Two-way talkback
- .6 Multicast send and receive
- .7 Configure up to 50-page zones
- .8 PoE powered (IEEE 802.3af)
- .9 Class-D Amplifier
- .10 Smart relay input for accessories
- .11 Upload custom audio files for announcements and alert tones
- .6 Mounting: Blind mounts into 8" (20.5 cm) hole. Clearance requirement of 5.5" (14.0 cm) above 1/2" (1.27 cm) gypsum board ceiling.
- .7 Compliance: RoHS, CE, FCC Class A, CISPR 22 Class A, CISPR 24, CSA/UL (USA & Canada), EN60950.
- .8 Accessories: Provide compatible accessories, such as call button, call switch, volume control, etc., as required to ensure functionality.
- .9 Finishes: White.

2.2 IP Horn Speakers

- .1 Digital PoE IP Horn Speakers shall be supplied, installed and connected by the Contractor.
Manufacturer: Algo Communication Products Ltd.
Model: 8186
Link: <https://www.algosolutions.com/product/8186-ip-horn-speaker/>
 - .2 The 8186 wall mounted IP Horn Speaker is an outdoor-rated IP speaker for voice paging, emergency, and loud ringing applications. The speaker is a fully compliant 3rd party SIP endpoint. As a result, this IP ceiling speaker is compatible with most hosted / cloud and premise-based VoIP telephone systems.
 - .3 An embedded microphone allows the 8186 to monitor ambient noise where volume is automatically adjusted according to background noise levels for paging and alerting. The microphone may also be used for two-way talkback.
 - .4 Speakers Features
 - .1 Wideband HD audio (G.722 voice codec) for high intelligibility speech
 - .2 Secure SIP using TLS and SRTP
 - .3 Configurable via user-friendly web interface or auto-provisioning
 - .4 Ambient noise response to automatically adjust audio output level
 - .5 Two-way talkback
 - .6 Multicast send and receive
 - .7 Configure up to 50-page zones
 - .8 PoE powered (IEEE 802.3af)
-

- .9 Class-D Amplifier
- .10 Smart relay input for accessories
- .11 Upload custom audio files for announcements and alert tones
- .5 Mounting: Wall, ceiling, or double gang electrical box.
- .6 Compliance: RoHS, CE, FCC Class A, CISPR 22 Class A, CISPR 24, CSA/UL (USA & Canada), EN60950.
- .7 Accessories: Provide compatible accessories, such as call button, call switch, volume control, etc., as required to ensure functionality.

PART 3 EXECUTION

3.1 Installation of Ceiling Speakers

- .1 The 8188 IP Ceiling Speaker is intended to be mounted in a T-bar acoustic tile, gypsum ceiling, or suspended from a ceiling or truss. The speaker can be secured to the ceiling tile by itself, however, for additional support, the speaker may also be tethered using a chain or cable via a 1/4" eye bolt screwed into the speaker.
 - .2 Before wiring or mounting the 8188, make sure the speaker trim is secured. The removable trim ring must be snapped into place to be flush with the front surface of the speaker. To do this:
 - .1 Lay the trim ring on a flat surface with the ribs facing down and place the speaker in the middle with the speaker facing up.
 - .2 Align the four tabs with the cavities on the speaker housing and slide the trim ring up to the speaker housing until it snaps into place flush with the top.
 - .3 The 8188 has an RJ45 jack for network connection. A cable run from the switch can be terminated in one of two ways: 1) to a modular jack with connection by patch cord or 2) terminated with an RJ45 plug.
 - .4 There are two lights on the Ethernet jack:
 - Green light - On when Ethernet is working. Flickers off to indicate activity on the port.
 - Amber light - Off when successful 100 Mbps link is established. Typically only on briefly at power up.

Under normal conditions, the amber light will turn on immediately after the Ethernet cable is first connected. This indicates that PoE power has been successfully applied. Once the device connects to the network, the amber light will turn off and the green light will turn on. The green light will flicker to indicate there is traffic on the network.
 - .5 Coordinate RJ45 outlet and structured cabling requirements with vendor responsible for providing structured network cabling system. Install telecom jack at each IP based equipment and extend telecom UTP cabling back to LAN equipment serving area. Refer to section 27 10 00 Structured Cabling for product and installation requirements.
 - .6 The protective wiring cover may be attached after connections are made. The cover helps prevent any water drips from HVAC or roof leaks from entering the enclosure, as well as keeping dust out of the connections. The cover also provides additional strain relief for the wiring.
 - .7 Install devices in accordance with manufacturer's instructions.
 - .8 Confirm the exact requirements and locations of the equipment with the Consultant and the U of T I&ITS prior to roughing-in.
 - .9 Quantities shall be as per the floor plan drawing.
-

- .10 When work is complete, arrange for attendance at the site of the system manufacturer's authorized representative to make final equipment connections.

3.2 Installation of Horn Speakers

- .1 Concealed wiring may enter the 8186 wiring cavity from the wall. Alternatively, surface wiring may enter through a channel from the bottom edge. The channel is intended for cabling 0.2" or 5mm in diameter and is intentionally snug to protect against moisture ingress.
- .2 The 8186 IP Horn Speaker can be mounted in any orientation, but both the bracket and housing must identify TOP. This keeps the bracket wiring channel on the bottom and the RJ45 jack on the top side. Orientation is extremely important as water needs to be able to drain through the bottom of the mounting plate.
- .3 The mounting plate may be used to mount over flush or surface-mounted electrical boxes or mud rings and fits securely to a 2-gang electrical box (not included) for installation with wiring conduit.
- .4 The 8186 IP Horn Speaker is rated IPX6 for wet locations, however, care must be taken to ensure that water does not enter the wiring cavity. The supplied gaskets or sealant must be used to protect the wiring cavity in wet environments. If sealant is used, ensure the bottom center area of the mounting plate is not obstructed, as water may need to drain out. In dry indoor environments the gaskets are not required. If the wall gasket is used with surface wiring, the gasket should be attached after placing the cable into the wiring channel.
- .5 The 8186 has an RJ45 jack for network connection. A cable run from the switch can be terminated in one of two ways: 1) to a modular jack with connection by patch cord or 2) terminated with an RJ45 plug.
- .6 There are two lights on the Ethernet jack:
 - Green light - On when Ethernet is working. Flickers off to indicate activity on the port.
 - Amber light - Off when successful 100 Mbps link is established. Typically only on briefly at power up.

Under normal conditions, the amber light will turn on immediately after the Ethernet cable is first connected. This indicates that PoE power has been successfully applied. Once the device connects to the network, the amber light will turn off and the green light will turn on. The green light will flicker to indicate there is traffic on the network.

- .7 Coordinate RJ45 outlet and structured cabling requirements with vendor responsible for providing structured network cabling system. Install telecom jack at each IP based equipment and extend telecom UTP cabling back to LAN equipment serving area. Refer to section 27 10 00 Structured Cabling for product and installation requirements.
- .8 Install devices in accordance with manufacturer's instructions.
- .9 Confirm the exact requirements and locations of the equipment with the Consultant and the U of T I&ITS prior to roughing-in.
- .10 Quantities shall be as per the floor plan drawing.
- .11 When work is complete, arrange for attendance at the site of the system manufacturer's authorized representative to make final equipment connections.

END OF SECTION

1 GENERAL

1.1 REFERENCES

- .1 International, national and local codes and standards:
 - .1 National Fire Code (NFC)
 - .2 CAN/ULC-S319-05 Electronic Access Control Systems
 - .3 CAN/ULC-S3-1-M88 Standard for Central and Monitoring Station Burglar Alarm systems
 - .4 ASTM F476-84(2002) Standard Test Methods for Security of Swinging Door Assemblies
 - .5 ASTM F571-87(2001) Standard Practice for Installation of Exit Devices in Security Areas
 - .6 Local Building Department
 - .7 Local Fire Department
 - .8 Electrical Safety Authority
 - .9 Other Municipality Bylaws
 - .10 CENELEC EN 50173 Information Technology: Generic Cabling Systems
 - .11 FIPS PUB 174 Commercial Building Telecommunications Wiring Standard
 - .12 ISO/IEC IS 11801A Generic Cabling for Customer Premises
 - .13 NEMA WC 63 Performance Standard for Field Testing of Unshielded Twisted-Pair Cabling System
 - .14 UL 294-1999, Standard for Safety for Access Control System Units.
 - .15 UL 1076-1995, Standard for Safety for Proprietary Burglar Alarm Units and Systems.
 - .16 ULC-S317-1996, Installation and Classification of Closed-Circuit Video Equipment (CCVC) Systems for Institutional and Commercial Integrated Security Management Systems.
 - .17 UL 60950 Standard for Safety of Information Technology Equipment
 - .18 ULC-S318-96 Power Supplies for Burglar Alarm Systems
 - .19 CIP-002-3 through CIP-009-3 – Critical Infrastructure Protection
- .2 American Society for Industrial Security (ASIS)
 - .1 ASIS/SHRM WVP.1-2011 Workplace Violence Prevention and Intervention ANSI Standard
 - .2 ANSI/ASIS/RIMS RA.1-2015 Risk Assessment
 - .3 ANSI/ASIS PAP.1-2012 Security Management Standard: Physical Asset Protection
 - .4 ANSI/ASIS CSO.1-2013 Chief Security Officer (CSO) Organizational Model
 - .5 ASIS FPSM GDL (2009) Facilities Physical Security Measures Guideline

1.2 SCOPE OF WORK

- .1 Provide a complete Security System(s) turnkey installation as detailed in this and other sections of these specifications. The Security System(s) shall comprise of the following systems:
 - .1 Wall mounted network enclosures for all provided equipment, including network switches, access control panels, intrusion detection panels, etc.
 - .2 A head end for the Physical Access Control System (PACS) is not required by the Security Contractor, as this is existing for the UofT campus.
 - .3 The PACS devices are shown for rough-in and cabling by the Electrical Contractor, who shall also engage the Security Contractor (item 4 below) for installation of PACS devices.
 - .4 Supporting networking, network cabling, signal conversion/transmission devices, servers, workstations, and associated peripherals as detailed on the Security System(s) drawings and specifications.
 - .5 For all systems, provide spare materials as detailed in the Execution section of the respective specification(s).
 - .6 Provide integration from the Security System(s) to other systems as follows:
 - .1 Connect Security System(s) components to building FAS and coordinate with FAS provider to ensure all SIS functionality is in compliance with Building Codes. Provide all necessary components and coordination.
 - .2 Connect Security System(s) components to barrier-free equipment and coordinate with barrier-free operator provider to ensure all functionality and sequencing is in compliance with Building Codes and does not cause electrical or mechanical conflict on each respective system. Provide all necessary components and coordination.
 - .7 Provide the following for all components of the Security System(s):
 - .1 Warranty on all components furnished, and maintenance/repair/replacement during the warranty period.
 - .2 Submittals, samples and record documentation.
 - .3 Comprehensive commissioning and testing with the Owner or Consultant during substantial completion.
 - .4 Training services for the Owner and Operators.
 - .5 Coordination with other site subcontractors.
 - .6 Reporting to the Owner, the Architect and Consultant for the coordinated and timely execution of the Work.
 - .7 All power supplies and conditioners, interlocking and control relays, equipment enclosures, conduit and cable trays, junction and mounting boxes, cabling, access doors, sleeves, fire stopping and other components, software, materials and services required for a completed and fully operational turnkey Security System(s) installation meeting these specifications.

1.3 GENERAL CRITERIA

- .1 The Security System(s) shall meet the following general criteria:

- .1 All Security System(s) control equipment, including but not limited to system control panels, networked devices, servers, workstations, interface devices, storage devices shall be fully IP networked, microprocessor based, and feature real time distributed processing. All networked devices shall reside on a converged facility network, provided as detailed in the Security System(s) drawings and these specifications.
- .2 The Security System(s) shall be configured to ensure reliability of systems operation and control of critical functions/systems. The following describes, in very general terms, a relationship between the various components of the Security System(s) that would be acceptable. Other Security System(s) topologies shall be acceptable if they meet the intent and performance requirements defined in these specifications.
- .3 Any Intelligent Control Panels (ICP's) shall be network based, communicate natively via TCP/IP, and connect to the Security System(s) LAN for communication to the PACS server. The network connection shall be via a direct on-board RJ-45 connection on the ICP. The use of code or protocol converters is not permitted.
- .4 Any Remote Modules (RM's) (specific system required control or monitoring panels if required) that are subcomponents of ICP's shall be directly connected to their corresponding ICP via dedicated cabling referred to as panel cabling. If physically possible, the RM's shall be located within the same room as the ICP, otherwise in approved locations as agreed upon by the owner and consultant.
- .5 Field devices connected to RM's or ICP's shall be directly connected via dedicated cabling. This cabling shall be compliant to the device's functional requirements, manufacturer's recommendations, and these specifications.

1.4 WARRANTY AND SERVICES DURING THE WARRANTY PERIOD

- .1 The Warranty Period for all components of the new Security System(s) and their installation shall be a minimum of one (1) year from the date of Substantial Performance. The date of Substantial Performance shall be the date when all components have been certified by the Consultant and accepted by the Owner to be complete in accordance with the definition of Substantial Performance.
- .2 All components and their installations shall be free from defects. Any defective material or workmanship and any resulting damage to work of other trades shall be replaced or repaired as directed during the Warranty Period. Comply with General Conditions, agreeing to repair or replace any components of the Security System(s) that have failed within the warranty period.
- .3 Schedule repair work with the Owner's representative to prevent interference with normal building activities.
- .4 The Base Tender price shall include the cost of all replacement parts during the warranty period and all of the associated installation costs and all of the costs associated with the repair of components during the warranty period but shall not include the cost of labour for routine maintenance during the warranty period. The cost of labour for routine maintenance during the warranty period shall be provided separately as an Alternate Price as detailed below.

- .5 Replace or repair all supplied defective installations. Respond and be on site within four hours of the Owner placing a system trouble call for items of a critical, urgent or immediate nature (e.g. failed head end component, non-functioning controller, etc.). Response to Warranty call out by the Owner shall be within 24 hours for items not requiring immediate attention. Work to trouble shoot and identify the cause of the Security System(s) or component failure shall begin immediately and shall continue until repaired to the satisfaction of the Owner.
- .6 Any software modifications or upgrades that become standard product offerings from the Security System(s) Contractor and/or Security System(s) equipment vendors during the warranty period shall be brought to the attention of the Owner and, at the discretion of the Owner, may be requested and, if so, shall be provided at no additional cost to the Owner.
- .7 The Security System(s) Contractor shall maintain an inventory of commonly replaced components in the local office for the replacement of failed components. Larger components shall be readily available within the North America for overnight courier shipping response.
- .8 Provide replacement components within the specified time periods for the following components. The Contractor shall guarantee to the Owner that the delivery of replacement components will be provided within the specified time periods.

Security System(s) Component	Delivery-Time (business days)
Computer Equipment (server/central computer components, workstations and components, primary communication components (network switches, fiber optic switches, NIC cards, etc.)	Five days
Head End Equipment (ICP's, RFP's, remote modules, secondary LAN components including any concentrators, protocol convertors, etc.)	Ten days
Field Equipment (card readers, detection sensors and devices, cameras, intercom stations, etc.)	Five days

1.5 CODES, PERMITS AND APPROVALS

- .1 Obtain all required permits, such as Magnetic Lock Installation Permits, and any other security –related inspection certificates. All permits and certificates shall be made available to the Owner.
- .2 The latest requirements of all national, provincial, county, municipal and other authorities having jurisdiction shall be met.
- .3 Work that is not clearly defined by local ordinance or amendment shall be governed by the local Building Code, and by the Authorities Having Jurisdiction (AHJ).

- .4 The requirements of The Occupational Health and Safety Act (OHSA), Environmental Protection Act (EPA), Americans with Disabilities Act (ADA), Accessibility for Ontarians with Disabilities Act (AODA) and CSA Barrier Free Design Standards shall be followed for all job-site procedures and installation methods.
- .5 Work shall be performed in compliance with Owner's insurance underwriters' requirements which will be provided to the successful Security System(s) proponent following project award.
- .6 All equipment and materials furnished under this subcontract shall be new and shall meet all applicable UL/ULC standards and all requirements of these specifications.

1.6 SCHEDULE

- .1 Complete all requirements of the Security System(s) subcontract prior to the scheduled Substantial Performance date for each portion of the work.
- .2 Provide to the General Contractor a schedule indicating the sequence of work, durations of individual tasks, delivery dates for all material, devices and equipment and detail any interface that must be coordinated with any other subcontractors.
- .3 Attend all project meetings as requested by the Owner and the General Contractor.
- .4 Provide written status reports at required intervals and in a format acceptable to the Owner. An updated schedule of work shall be included in each status report.
- .5 Comply with the Project Construction Schedule. Provide additional staff and work overtime as required to comply with the Project Schedule and so as not to interfere with other on-site subcontractors in their effort to comply with the Project Schedule.
- .6 Provide written Request for Information notices to the Owner when specific information or clarification of the specifications is required. Request for Information notices shall be provided at least two weeks prior to the need for the information.

1.7 CONTRACTOR QUALIFICATIONS

- .1 The Contractor shall:
 - .1 Be certified by the manufacturer to procure, install, program, maintain, and service the acceptable Security System(s) components.
 - .2 The Contractor must have permanent full-time certified staff available in the project area to perform all necessary project cycle installation functions, including service and maintenance work following system acceptance.
 - .3 Have staff and be able to supply information to support that their current installation and service technicians are competent factory trained and certified personnel capable of maintaining and servicing the proposed system.

- .4 Have a proven record of experience with similar in the supply and installation of equivalent systems over a minimum period of five years. Document at least three and no more than six projects, of equal or greater size and complexity, on the acceptable Security System(s) components. Indicate quantities of card readers, VSS cameras, and SIS units included in the scope of the projects along with a description of the property secured.
- .5 Have been a factory certified representative for the Security System(s) products indicated, for a minimum of three years entailing design, installation, configuration, and maintenance.
- .6 Have comprehensive local service and support facilities in the project area for the total Security System(s) as provided.
- .7 Maintain local supplies or have access to a factory authorized organization that shall carry a complete stock of essential and expendable parts.

1.8 INFORMATION TO ACCOMPANY TENDER

- .1 The information to be submitted for the Security System(s) tender shall include, at minimum, the following:
 - .1 Pricing summary for all systems and requested alternates listed in the Security System(s) tender documents.
 - .2 A summary of the bidding Contractor and qualifications, in compliance with the Contractor Qualifications requirements in section 1.12.
 - .3 Schematic diagrams of the Security System(s) configurations indicating all primary system elements and their locations.
 - .4 Specifications (data sheets) for all equipment to be provided.
 - .5 Details of the proposed Extended Service Contract if applicable.

1.9 SYSTEM COMPLIANCE AND PERFORMANCE CERTIFICATION

- .1 The Security System(s) Contractor shall thoroughly review all aspects of the Security System(s) Design Documents and certify that their bid submission and proposed Security System(s) facilities are in compliance with the Contract Documents. The Contractor shall provide a Compliance Review of all Specifications and Addenda as part of the Contractor's proposal. The Compliance Review will be an item-by-item list and review of the Specifications. The Security System(s) Tender Respondents shall clearly identify any areas where the proposed Security System(s) facilities are not in full compliance with the Security System(s) design. An accompanying performance statement and technical supporting documentation must be supplied for consideration.
- .2 In lieu of a full Compliance Review, one or more general Letter of Compliance may be supplied if the proposed system(s) are in full compliance with the issued drawings and specifications. A Letter of Compliance from the bidder, subcontractors, and manufacturers are acceptable.
- .3 Unless an exception is specifically noted in the Compliance Review, it is assumed that the Contractor is in complete compliance with the Contract Documents. Exceptions taken in cover letters, subsidiary documents, by omission, or by contradiction do not release the Contractor from being in complete compliance unless the exception has been specifically noted (explicitly, not by implication) in the Compliance Review.

1.10 DOCUMENTATION - GENERAL

- .1 The primary purpose of the shop drawing and equipment documentation submittals is to give instruction and information to those responsible for providing a turnkey Security System(s) which is compliant with the Security System(s) specifications in all respects. The Consultant shall review the shop drawings and equipment documentation submittals with the intent of identifying as many potential areas of non-compliance as possible, but the review of shop drawings and equipment documentation submittals by the Architect, Engineer and Consultant, shall not relieve the Contractor of the responsibility for complete compliance with the specifications. Identification of some errors by the Architect, Engineer and Consultant but overlooking others does not relieve the Contractor of his responsibilities nor does it allow him to proceed based on erroneous shop drawings and equipment documentation submittals.
- .2 Approval of shop drawings or submittal data by the Architect, Engineer or Consultant shall not constitute an order to fabricate, purchase, ship to the site or undertake any other action. The sole responsibility for the timely purchase and/or fabrication of components, obtaining approval on shop drawings and equipment documentation submittals, and delivery of components to the project to comply with the requirements of the project schedule is that of the Contractor.
- .3 The intent of the record documentation is to provide the Owner with complete information on the Security System(s) provided such that a person familiar with installations of this nature shall be able to perform any operating, maintenance or engineering functions with respect to this Security System(s) without having to contact the Security System(s) Contractor or obtain any additional documentation.

1.11 SHOP DRAWING AND EQUIPMENT DOCUMENTATION

- .1 Prepare all shop drawings, diagrams, equipment and device schedules, equipment technical data sheets and software information necessary for the Consultant to determine compliance with the specifications. Submit all shop drawings and equipment documentation data together as one submittal within four (4) weeks after notice to proceed.
- .2 The following information shall be included on the cover page for each shop drawing and equipment documentation sheets:
 - .1 Project name.
 - .2 Date.
 - .3 Submittal number and re-submittal number as appropriate.
 - .4 Name and address of Consultant.
 - .5 Name and address of General Contractor.
 - .6 Name and address of Security System(s) Contractor.
 - .7 Name and address of supplier or vendor if appropriate.
 - .8 Name of manufacturer.
 - .9 Reference to the applicable Specification Section by name and number.

- .3 Shop drawings shall be CAD generated and be clearly referenced to each other and shall include diagrams, mounting instructions, installation procedures, equipment details and software descriptions for all components of the system. AutoCAD floor plan drawings shall be provided to the Contractor. Shop drawings shall be in this order and at a minimum include:
 - .1 Cover page with required information identified above.
 - .2 Floor plan drawings in same order and format as architectural drawings. Floor plans shall indicate each Security System(s) field device location. Uniquely identify each cable type for each field device. Identify desired cable routing from each device to termination location. Update these drawings to reflect actual routing location on as-built submittals.
 - .3 Provide a chart-based schedule on each floor plan drawing or on a separate drawing sheet prior to the floor plans with, at minimum, the following columns for:
 - .1 PACS:
 - .1 Point reference.
 - .2 Device type (card reader, door contact, local alarm, etc. with manufacturer/model number).
 - .3 Lock/control type (manufacturer/model number) if appropriate.
 - .4 Request to exit device type (manufacturer/model number) if appropriate.
 - .5 Special accessories.
 - .6 Cable type (manufacturer/model number).
 - .7 Cable colour and labelling scheme.
 - .2 VSS:
 - .1 Point reference.
 - .2 Camera type (manufacturer/model number).
 - .3 Fixed or PTZ.
 - .4 Lens size and type (manufacturer/model number).
 - .5 Housing type (manufacturer/model number).
 - .6 Mount type (manufacturer/model number).
 - .7 Special accessories.
 - .8 Cable type (manufacturer/model number).
 - .9 Cable colour and labelling scheme.
 - .4 Separate wiring schematic diagram for each system. Include all types of controllers, panels, interfaces, and interconnection locations to head-end equipment.
 - .5 Separate Riser diagrams for each system including general layout and configuration of each system indicating major component locations and relationships.
 - .6 Detail installation diagrams of all monitoring and control equipment for each monitoring and control equipment location. Include routing of wiring.
 - .7 Security System(s) data communications network architecture diagram indicating all NDS's, OIW's, SAN devices, ICP's, video encoder/decoder units, CIS's, other network connected devices, network switch and network interface connection points.

- .8 Wiring diagrams and installation drawings for each component.
- .4 Equipment documentation submittals shall include design, performance and installation details for all aspects of the system to be installed. At minimum, the submittals shall include:
 - .1 Bill of Quantities with name and address of supplier or vendor for each device.
 - .2 Equipment technical data sheets.
 - .3 Central monitoring and control equipment.
 - .4 Operator workstation specifications and data sheets.
 - .5 Software specifications and descriptions.
 - .6 Training outline.
- .5 Literature pertaining to a particular item, piece of equipment or installation shall be submitted at one time and shall be specifically prepared for this project. Each submittal shall be properly marked with service or function, any options available that are not to be provided shall be crossed out or options that will be provided shall be highlighted.
- .6 Comply with the requirements of the Contract Documents. Any deviations from the Contract Documents will not be allowed. Submittals not in accordance with the Contract Document requirements shall be rejected. Before equipment, devices and materials are installed; they shall have submittals that are stamped "No Comment" or "Make Revisions Noted". "No Comment" or "Make Revisions Noted" submittals containing errors and/or omissions shall not relieve the Contractor from the requirements to comply with the complete requirements of the specifications. Corrections or modifications to the work because of errors and/or omissions shall be at the Contractors expense.
- .7 Each submittal shall be reviewed, and electronically stamped and certified by all applicable parent contractors prior to submission to the Consultant. The stamp shall certify that the equipment submitted complies in all respects with the requirements of the Contract Documents for this Project.
- .8 Submit electronic copies of all shop-drawing submittals to the Architect, Owner, Consultant, General Contractor, General Contractor Project Manager, and Electrical Sub-Contractor.
- .9 Shop drawings or equipment documentation submittals returned that are noted " No Comment " on " Make Revisions Noted ", do not require additional review.
- .10 Shop drawings or equipment documentation submittal data that are noted "Revise and Resubmit", will require additional review. Resubmit all shop drawings and equipment documentation submittals noted "Revise and Resubmit". If more than two reviews are required for any shop drawing or equipment documentation submittals, the Contractor shall reimburse the Owner for any additional fees and expenses required from the Architect, Engineer or Consultant in performing the additional reviews.

1.12 RECORD DOCUMENTATION

- .1 At minimum, the record documentation shall include all submittals (shop drawings and equipment documentation) made at the shop drawing stage updated to reflect the actual installation and the manuals outlined below.

- .2 A draft version of the record documentation shall be submitted to the Consultant at the time of the request for acceptance testing. Following the acceptance testing and, if necessary, the subsequent rechecking of deficiencies, the Security System(s) Contractor shall re-submit the record documentation incorporating all changes resulting from the acceptance testing and any other changes requested by the Consultant as a result of the consultant's review of the draft version of the record documentation. The Certificate of Substantial Performance shall not be granted until the final approved record documentation has been received.
- .3 Update all documentation to indicate any changes made during the Warranty Period.
- .4 Provide record documentation in manuals. Manuals shall be placed in hard cover binders with index page and indexing tabs along with two electronic PDF file format copies on a USB flash drive. Provide record document types and quantities as indicated below:
 - .1 Operators' Manuals (three (3) copies).
 - .2 Managers' Manuals (which includes the Operators' Manuals – three (3) copies).
 - .3 Hardware Manuals (three (3) copies).
 - .4 Security shop drawings in binders (11" x 17" tabloid size colour printed – two sided – three (3) binder copies)
- .5 Provide Operators' and Managers' Manuals with, at minimum, the following information:
 - .1 Details of all features and functions available to the Operators and Managers.
 - .2 Details of all alarm, diagnostic, error and other messages. Detail the Operator action to be taken for each instance.
 - .3 Detail special programs provided and provide a complete programming instruction manual. Detail operations of all software applications.
 - .4 Detailed listing of the database for all installed devices.
 - .5 Details of all data base management functions and features.
 - .6 All details and descriptions shall be in a step-by-step format such that an Operator or Manager shall be able to respond to and undertake the respective actions on the basis of information provided in the manuals and drawings.
 - .7 Provide hardware manuals that shall include, at minimum, the following:
 - .1 Details of all specifications including maintenance and installation requirements for all computers, field panels, equipment, devices, interfaces and facilities provided.
 - .2 Record drawings and schedules of the completed installation including location of devices, mounting details, and wiring details.
 - .3 Operating sequences and interlocks.
 - .4 Names and addresses of spare parts suppliers.
 - .8 Record drawings shall be CAD generated, pdf printed, based on the latest version of AutoCAD and shall include, at minimum, the following:
 - .1 Details required by the shop drawings.
 - .2 Final locations and point ID for each monitored and controlled device.

END OF SECTION

1 **GENERAL**

1.1 **SUMMARY**

- 1.1.1 This section of the specifications details the work and components to be provided by the Security Contractor relating to the Physical Access Control System (PACS).

1.2 **RELATED SECTIONS**

- .1 The requirements of the Project Manual are related to and shall be read in conjunction with this section.
- .2 This section is related to and shall be read in conjunction with all other Division 28 sections.
- .3 This section is related to and shall be read in conjunction with the Security drawings.

1.3 **SYSTEM DESCRIPTION**

- .1 The PACS system shall be installed to meet the requirements of these Specifications and Security drawings shall include all software, hardware, Intelligent Control Panels (ICP), Remote Field Panels (RFP), Remote Modules, field devices, sensors, and other components to provide a turn-key operating PACS system.
- .2 The PACS shall be designed in a modular fashion, such that addition and expansion to the PACS by adding components shall not require substantial modification of other components such as Server or Client equipment, or other ICP's and RFP's.
- .3 The PACS shall be capable of running on a TCP/IP network and shall be accessible, configurable, and manageable from any network-connected PC via a browser or client software on the same network.
- .4 The PACS shall monitor and control facility access, and shall perform alarm monitoring, communications loss monitoring. The system shall also maintain a database of system activity, personnel access control information, system user information, user permissions, and other relevant data.
- .5 All card access requests, alarms, events, actions, commands, and responses shall be completed within two (2) seconds of being triggered. This shall occur across the entire PACS and its components and shall not be affected by system activity at any given time.
- .6 The database of system activity, personnel access control information, system user passwords, user role permissions, and other relevant data shall be of a commercially available relational database management system that supports ODBC and shall run on the same equipment as the PACS Server/Controller.
- .7 The system shall be controlled from a web browser or client software and provide control and access to users on Local Area Networks (LAN), Wide Area Networks (WAN), wireless networks, and the Internet.

- .8 The system functions shall take place in a point-and-click interface, using a standard PC mouse and keyboard combination.
- .9 The PACS Server/Controller shall serve as the central component of the PACS. The PACS Server or Controller contains an operating system, the security application software, and the database of personnel and system activity.
- .10 The PACS Server shall be installed on a rack-mountable server-grade computer meeting all the manufacturer's system requirements.
- .11 The PACS Client workstation shall serve as the monitoring component of the PACS. The Client software allows administrators and users to interact with the PACS Server/Controller, allowing for system configuration, management, and real-time monitoring of PACS events.
- .12 The PACS Client shall be installed or used on a desktop-grade computer with equipment to suit the purpose (i.e. multi-monitor, camera, credential printer, enrollment reader, peripherals, etc.) of the station.
- .13 The PACS Server and Client software shall be installable or embedded on commercially hardware platforms, on a Windows or Linux based operating system which is part of the operating system manufacturer's support cycle at time of install.
- .14 The system shall be capable of being integrated to a Windows Active Directory (LDAP) server for single sign logon authentication. If activated in such a way, password and authentication will be controlled by the LDAP server.
- .15 The system shall be capable of being divided into partitions, allowing subsets of the overall system and components to be managed separately. Partitions of the system shall be capable of being assigned access rights, so that user level logins, where restricted, can only view partitions for which they are authorized.
- .16 Configuration of all system components shall follow a hierarchical format, where an object which logically belongs to a higher-level object can inherit the property of its "parent" object. This shall apply to, but not be limited to, partitions, logical groupings of system objects, schedules, access levels, card holders, and system users.
- .17 Each field device on the system shall be defined as active/inactive, secure/released, alarmed/suppressed as required by the function, on an as required basis via the operator, or based on a time schedule. Field devices shall be controllable individually, or as part of one or more groups.
- .18 The system shall be capable of providing email and/or text message alerts for all alarm conditions and threats.
- .19 All equipment and materials comprising the PACS system shall be standard components, regularly manufactured, stocked, and utilized in the manufacturer's system.
- .20 All PACS components shall have been thoroughly tested and proven in actual installations.

1.4 SUBMITTALS

- .1 For Submittal requirements refer to specification Section 28 00 00.

1.5 WARRANTY

- .1 All PACS components shall be provided with a minimum manufacturer warranty of one (1) year.

2 PRODUCTS

2.1 MANUFACTURERS

- .1 Subject to compliance with these specifications, PACS hardware, and related components as manufactured by the following system manufacturing companies shall be considered for the work of this project:
 - .1 Salto
 - .2 No accepted alternates

2.2 CARD READERS

- .1 Provide PACS proximity type card readers at locations indicated on the security drawings. Proximity card readers shall meet, at minimum, the following requirements:
- .2 Provide contactless smart card technology card readers at locations indicated on the Security Drawings. Types are as follows:
 - .1 Salto WRD90 Series Reader with XS4 Series Controller.
 - .2 Salto XS4 Original+ Series mortise locks with integral readers and associated gateways.

2.3 ELECTRIC LOCKS

- .1 Electric door locking hardware (magnetic locks, electric mortise locks, electric strikes, etc.) shall be provided under a separate contract, except where mortise locksets with integral readers are indicated.
- .2 Coordinate lock and door hardware with the general contractor and all door hardware subcontractors and review each security device location as shown on the Security Drawings to ensure the proper door hardware is provided at required locations.
- .3 Provide and terminate relay output cabling from the ACAMS ICP/RFP to the electric door locking hardware.

2.4 AUTOMATIC DOOR INTERFACE

- .1 Automatic door operators shall be provided under a separate contract. Provide and terminate interface cabling from the ACAMS ICP/RFP to the door operator.

2.5 REQUEST TO EXIT DEVICE

- .1 Supply and install request to exit device and signal cabling from the ACAMS ICP/RFP.
- .2 Request to exit motion detectors shall be programmed not to release the electric strike upon motion detection. The request to exit shall act as a door position alarm shunt upon motion detection only.

2.6 DOOR POSITION SENSORS

- .1 Door position sensors for security doors shall be provided and terminated.
- .2 Provide and terminate door status sensors from the ACAMS ICP/RFP to the mounting location at the door.
- .3 For revolving doors, provide all conduit, cabling, and input connections from monitoring terminals of the revolving door controller to the ACAMS.
- .4 For overhead (roll up) doors, provide all conduit, cabling, and input connections from the overhead door contact to the ACAMS. Overhead door contact shall meet, at minimum, the following requirements:
 - .1 Surface mounted SPDT magnetic contact switch.
 - .2 Cable lead shall be encased in stainless steel armored cable.
 - .3 Gap reading distance of 75mm (3")
 - .4 Position switch shall be General Electric Series 2200 or approved equal.

2.7 SECURITY CABLING

- .1 Supply and install all cabling required for security field devices, panels, and connectivity unless otherwise noted.
- .2 Security cabling shall be stranded only, solid cabling not permitted, and be suited for security installation purposes.
- .3 All security cabling shall be installed complete with a pull string to facilitate future changes.
- .4 Security cabling shall meet, at minimum, the following requirements:
 - .1 Access control composite door cabling
 - .1 Honeywell Genesis Profusion 3307
 - .2 Belden Profusion 658AFJ
 - .2 Door position sensors, input or alarm devices (unpowered)
 - .1 22AWG 2-conductor stranded unshielded
 - .3 Input or alarm devices (powered)

- .1 22AWG 2-conductor stranded unshielded, 18 AWG 2-conductor stranded unshielded
- .4 Electrified hardware
- .1 18AWG 2-conductor stranded unshielded, upsize AWG as required to meet distance and voltage drop requirements.

3 EXECUTION

3.1 INSTALLATION

- .1 Implement all software and provide all applicable licenses to provide a fully operational system. Where information is required from the Owner to implement the software, request such information in writing at least one (1) month prior to the need of such information.
- .2 Programming of the database, the Contractor shall provide a proposed device naming standard to the Consultant and Owner for approval. The naming standard shall be based on the naming standard used in the Security drawings and expanded to accommodate all the components of the PACS.
- .3 The initial cardholder database information and all other required database information shall be entered into the system by the Contractor. The Contractor shall provide all work required for the development of PACS database(s) including individual cardholder file data entry and door control access level definition, as required for a fully functional and turnkey PACS installation.
- .4 The Contractor shall provide the initial administration level training, as identified in the training section of these specifications, to familiarize the Owner's staff with the database structure, cardholder file information, access levels, time zones, capabilities etc. The Contractor shall develop the required time zones, access groups, access levels, the cardholder information, database definition, etc. The Contractor shall develop blank forms for all required database and cardholder information and submit them to the Owner. The Contractor shall then enter the information.

END OF SECTION

1 GENERAL

1.01 REFERENCE

- .1 Section 26 00 10 applies to and is a part of this Section of the Specification.
- .2 Section 26 05 00 forms a part of this Section and contains requirements, products and methods for execution that apply to this Section.

1.02 SUBMITTALS

- .1 Submit shop drawings for products specified in this Section.

1.03 SOFTWARE NOMENCLATURE REPROGRAMMING

- .1 Include additional costs for system manufacturer to make necessary on-site final changes to applicable system/equipment software. Make such changes after successful testing and verification of systems, but prior to turn over to Owner. After successful final verification of work, confirm and obtain approval of final nomenclature in writing from Owner and Consultant. Software revisions to incorporate final room names/area names/building names and equipment identification

2 PRODUCTS

2.01 EXISTING FIRE ALARM SYSTEM

- .1 Existing fire alarm system serving complex is manufactured by Chubb-Edwards. Provide additional devices and work to extend system to serve additional and renovated areas. Additional devices to be 100% compatible with and of same manufacture as per existing system. Include provision of necessary control panel and annunciator work of existing system to accommodate integration of additional devices.
- .2 Include for and engage Owner's existing system manufacturer's authorized technicians to provide and perform required system products and work. Contact the University of Toronto fire prevention services to coordinate any work.
- .3 Verify with existing fire alarm system manufacturer during Bid period, exact requirements needed to provide renovation work. If necessary, visit site with manufacturer to review existing conditions. Confirm and coordinate exact work responsibilities with system vendor. Items of clarification or proposed revisions to Bid Documents must be reviewed with Consultant during Bid Period.

2.02 ADDITIONAL FIRE ALARM SYSTEM WORK

- .1 All fire alarm system devices and control units shall be purchased by the Contractor, directly from the manufacturer.
- .2 System work to include but not be limited to provision of following:
 - .1 modifications to existing head end equipment including provision of additional device connection modules, zone modules, amplifiers and system re-programming;

- .2 review of existing battery backup capacity and amplifiers (as applicable) and increasing capacities to accommodate additional device loading and to meet applicable governing local code requirements;
- .3 additional wiring in conduit and/or fire rated cables.
- .3 Additional system components to be listed as products of a single manufacturer under appropriate category, by Underwriter's Laboratories of Canada and bear ULC label. System components and work in conjunction with system installation to meet specific application requirements of local governing authorities, codes, standards, regulations and requirements of following:
 - .1 CAN/ULC-S524, Standard For Installation Of Fire Alarm Systems;
 - .2 CAN/ULC-S537, Standard For Verification Of Fire Alarm Systems ;
 - .3 local governing building code;
 - .4 local governing electrical code;
 - .5 local governing building permit applications for approvals;
 - .6 other requirements of local governing authorities.
- .4 Acceptable manufacturers and model numbers
 - .1 Chubb-Edwards EST-3 series for systems with more than 8 zones or those using addressable devices.
 - .2 Chubb-Edwards EST-FS fireshield series for systems with 1-8 zones provided building is not sprinklered.
 - .3 Verify system selection with University of Toronto Fire Prevention during conceptual design stage.
- .5 All fire alarm system devices and control units shall be purchased by the Contractor, directly from the manufacturer.
- .6 Upgrades or retrofit work shall utilize active field devices, using analogue addressable technology, if budget permits. Data communication links for active field devices shall be configured in a DCLA style as defined by CAN/ULC-S524. System installation shall conform to CAN/ULC-S524.
- .7 System Operation: match existing unless otherwise approved by University of Toronto Fire Prevention. Manual signal silence only (no automatic silence feature).

2.03 MODIFICATIONS AND DEVICES

- .1 Modify control panels and annunciators to supervise and annunciate additional and relocated devices. Additional initiating devices shall be devices that are 100% compatible with existing controls and be ULC listed and labelled for connecting to respective control units. Include costs for manufacturer's authorized representative to perform control panel/transponder work and to reprogram system software to accommodate renovation work. Provide additional zone modules as required and additional batteries as required to supply back-up battery capacity to the additional components.

- .2 Additional devices to be ULC listed and labelled devices suitable for fire alarm applications. Power supplies and other components to be CSA approved where required by local governing authorities and codes.
- .3 Exact type of device to be used in each area of installation to be as recommended by system manufacturer to suit specific applications and to be approved for such use as per ULC standards. Devices in non-climatic controlled areas to be weatherproof, corrosion resistant and ULC listed for use in below freezing temperatures. System manufacturer to be responsible for ensuring compliance with these requirements.
- .4 Zone and active field device descriptions for annunciation & LCD programming are to be coordinated with and approved by U of T Fire Prevention.
- .5 Devices:
 - .1 Additional smoke detectors and heat detectors: to be of type and rating to suit specific application as per existing system manufacturer's recommendations. Automatic detection in elevator shafts shall be accomplished with heat detectors. Smoke detectors shall be only photoelectric type.
 - .2 Audible devices: of type to match existing system standards.
 - .3 Strobes and combinations strobes/audible devices: of type to match existing system standards; include additional strobes to meet latest governing building code requirements;
 - .4 Addressable modules as required for connection of additional devices.
 - .5 Ancillary devices as required to complete system.
 - .6 Refer to drawings for additional device requirements.
- .6 End-Of-Line Resistors and Isolators:
 - .1 End-of-line resistors for standard alarm and signalling circuits to be sized to ensure correct supervisory current flows in each circuit.
 - .2 End-of-line resistors to be mounted on a stainless steel plate for mounting on a standard single gang box and bear ULC label.
 - .3 Isolators to be provided in accordance with code requirements and installed as per system manufacturer's requirements to isolate/monitor zones, loops, group of devices within building and between buildings.
- .7 Wiring:
 - .1 CSA approved and ULC listed wire and cable, approved for fire alarm circuits; with colour coded, insulated solid copper conductors; of type as per local governing electrical code and local governing fire authority requirements.
 - .2 Sized and installed in accordance with system manufacturer's instructions and local governing electrical code.
 - .3 To be mechanically protected to satisfaction of local fire authority.

- .4 Fire rated MI for wiring as required by local governing building code, local governing authorities and as noted on drawings, for connections and interconnections to equipment for life safety applications.
- .5 Pentair "Pyrotenax" type "MI" ULC listed and labelled, 2 hour fire rated, mineral insulated, copper sheathed, copper conductors for power, control and signal wiring to and between each transponder/control panel, and for other local code required or local governing authority required applications with regards to life safety equipment.

2.04 TESTING AND VERIFICATION WORK

- .1 Refer to Part 3 for system testing, verification and certification Work.

3 EXECUTION

3.01 INSTALLATION – GENERAL

- .1 Prior to start of Work as part of shop drawing submission process, review with system manufacturer following:
 - .1 device types to ensure that selected type is suitable for intended application on project;
 - .2 locations of devices to ensure proper operation and coverage are in compliance with requirements of local fire authorities;
 - .3 device mounting heights to ensure proper operation and coverage are in compliance with requirements of local fire authorities;
 - .4 device back box requirements to ensure size and depth suit system manufacturer's recommendations for specific devices;
 - .5 proposed revisions required to existing system sequence of operation.
- .2 Immediately advise Consultant of any requirements of above that may necessitate revisions to design documents.
- .3 Install fire alarm system components and connect complete.
- .4 Perform Work in conjunction with this installation to meet requirements of latest editions of local governing building code, local governing electrical code, ULC Standards including Installation Standard CAN/ULC-S524, and any applicable local governing codes. If any requirements of these specifications are different, omitted or contrary to ULC-S524 Standard, then ULC Standard governs and overrides these specifications, but in no instance will standards established by drawings and specifications be reduced by any of Codes referred to previously.
- .5 During work to existing fire alarm system, proposed time and duration of interruption to be approved by Consultant. At any time due to emergency situations, Owner may request by-passed zone(s) to be re-instated immediately. In all areas where renovation work requires shutdown of any part of fire alarm protection system, provide manual fire alarm protection (Fire Warden) by means of supervising area as approved by local governing authorities. At no time allow fire alarm system or any one (1) zone to be left inoperative overnight.

Provide required bypass wiring and temporary wiring to maintain all parts of fire alarm system operative during construction and alterations.

- .6 Fire alarm system manufacturer's authorized technician to supervise control panel, transponder, and annunciator work.
- .7 Provide sequence of operation for fire alarm system as approved by local fire authority and reviewed by Consultant. Refer to additional requirements on drawings.
- .8 Demonstrate system to local Fire Department and obtain their approval for complete system.

3.02 INSTALLATION OF DEVICES

- .1 Install required devices. Do not install devices in locations that may hamper proper operation of devices including adjacent devices.
- .2 Obtain required training from manufacturer's representative on any special installation procedures. Install devices and perform work in accordance with manufacturer's instructions and requirements and in accordance to applicable codes of local governing authorities having jurisdiction.
- .3 Confirm device finishes with Consultant prior to ordering.
- .4 Install manual pull stations in boxes as required, recessed outlet boxes with plaster rings, except in unfinished areas where pull stations are surface mounted, in which case, install stations in surface mounted boxes. Comply with mounting height requirements for local governing building code barrier free access.
- .5 Install mounting plate of thermal detectors to ceiling mounted boxes as required. Secure detectors to plates. Refer to floor plans and drawing symbol list to determine rating of detectors in any given area. Generally, do not install rate-of-rise type detectors in areas subject to sudden changes in temperatures, such as entrance vestibules. Confirm application requirements with system manufacturer and ensure that devices are ULC listed for such applications and are approved by local fire authority for such use.
- .6 Secure base of each ceiling mounted products of combustion detectors to boxes as required, either flush or surface mounted as required. Secure detector heads to bases.
- .7 Mount each duct mounted products of combustion detector on duct in question and connect with smoke sampling tubes which extend into duct air stream. Install a remote alarm lamp assembly for each duct mounted detector. Wall mount each lamp assembly on a standard 100 mm (4") outlet box as close as possible or practicable to detector. Do not locate duct detectors within 1 m (3') of duct size increaser or decreaser fittings or any duct elbow. Provide wiring in conduit and extend to connect back to system control unit.
- .8 Provide required audible devices. Devices are flush and surface wall mounted bells to suit architectural wall types, each complete with a proper backbox. Install bells in accordance with manufacturer's instructions for specific applications.
- .9 Wire audible devices in Class B, 2 wire circuit configuration, terminating in end of line devices. Wire alternate speakers in same circuits with a minimum of 2 circuits per floor.

- .10 Generally, audible device locations are indicated on drawings, however, exact audible device quantities and locations to be in accordance with results of audibility device coverage site tests. Provide suitable sound detection metering and personnel to make necessary tests. Relocate audible devices and/or provide additional audible devices as required.
- .11 Install amplifiers sized as required to power additional bells and include spare capacity as specified.
- .12 Install specified telephone handsets and mount in recessed wall mounting boxes. Connect complete with wiring in conduit to local transponder.
- .13 Provide double voltage relays, with multiple contacts as required, to shut down fans as noted on drawings. Arrange relays to be energized at all times from fire alarm system to ensure that they are fail safe.
- .14 Install visual notification appliances 2400 mm (8') above floor or 300 mm (12") below finished ceiling line. Provide visual notification devices in areas subject to high ambient noise levels, such as mechanical equipment rooms, computer equipment rooms, parking garage, etc., and areas designated for hearing impaired as per local building code requirements.

3.03 REQUIREMENTS FOR CONDUITS AND WIRING

- .1 Fire alarm system conduits shall be identified every 3 metres by a band of red tape or other means deemed acceptable in writing by U of T Fire Prevention. Junction boxes for fire alarm system wiring shall be similarly identified or marked "F/A". Signal circuit wiring shall be run in a separate conduit from initiating circuit wiring or communication wiring (including active field device wiring).
- .2 Where fire alarm junction boxes will normally be inaccessible, properly identified access hatches shall be provided. Locations of access hatches shall be shown on as-built drawings and shall be identifiable in the field by permanently affixed markings to the approval of University of Toronto Fire Prevention.
- .3 All conduits shall enter the fire alarm control units from the bottom of the cabinet. Two additional knockouts shall be punched in the bottom of each cabinet, and fitted with a wire mesh screen in order to protect system components from possible water damage that may enter the control panel via conduits. Fire alarm control units shall be protected from sprinkler discharge by adequate drip trays.

3.04 REQUIREMENTS FOR INTEGRATED SYSTEMS AND EQUIPMENT

- .1 Perform required fire alarm system wiring connections to mechanical equipment and other building systems to perform required interrelated functions. Provide required wiring, relays and/or contactors between fire alarm system and various equipment to achieve automatic or manual control of equipment, to perform required integrated to fire alarm system functions. Provide shunt trip breakers as required. Provide fire rated conductors where required by local codes and local authorities.
- .2 Provision of fire alarm supervisory wiring connections to include but not be limited to following (where applicable):
 - .1 fire protection system piping supervised valves and flow switches for alarm initiation;

- .2 fire protection system piping supervised valves and flow switches for trouble indication;
 - .3 fire protection piping pressure detectors for loss of pressure trouble indication;
 - .4 fire/smoke dampers;
 - .5 door hold open devices;
 - .6 elevators;
 - .7 HVAC system equipment;
 - .8 devices as shown on drawings.
- .3 Integrated Systems Testing
- .1 Where fire protection and life safety systems, and systems with fire protection and life safety functions, are integrated with each other, the systems shall be tested as a whole in accordance with CAN/ULC-S1001, "Integrated Systems Testing of Fire Protection and Life Safety Systems", to verify that the systems have been properly integrated.
 - .2 Where a building undergoes renovation, or when existing fire protection and life safety systems are retrofitted/upgraded, there is a potential impact on the integrations between systems. For system modifications, CAN/ULC-S1001 requires that an Integrated Systems Test be performed only for those devices that were impacted by the modification.
 - .3 CAN/ULC-S1001 requires that Integrated Systems Test be documented and amalgamated into an Integrated Systems Testing Report. This report includes the Integrated Testing Plan, records of testing, and system documentation gathered from the design professionals, installing contractors, and system verifying parties.
 - .4 The tester needs to be certified to the ULC standard.

3.05 ADDITIONAL REQUIREMENTS

- .1 Install wiring in conduit unless otherwise directed by Consultant. Perform wiring connections associated with fire alarm system on terminal strips in junction boxes and colour coded. Provide wiring colour coding consistent for entire length of each run. When pulling wires into conduit, use lubricant and run wires straight and not twisted or abraded. Neatly secure exposed wires in apparatus enclosures with approved supports or ties. Clearly identify wiring at each termination point. In addition, number wiring with Brady Ltd. or Electrovert Ltd. Z-type markers. Colour conductors for each part of system in accordance with system equipment manufacturer's recommendations. Paint conduit couplings red of paint type suitable for application to standards of Division 09.
- .2 Install wiring in accordance to requirements of applicable governing electrical code and to requirements of local governing authorities.
- .3 Run alarm indicating circuits (speakers) and alarm receiving circuits (pull stations, detectors) in separate conduits from each other.

- .4 Arrange sprinkler system alarm valve alarm zones to be separate from manual station, thermal detector and products-of-combustion detector device zones, which may be connected together into zones.
- .5 Provide engraved Lamacoid identification nameplates for each equipment or wiring housing and secure to front of housing. Confirm exact wording designations and sizes to with Consultant prior to manufacture.
- .6 Verify nomenclature of annunciator identification with Consultant prior to ordering.
- .7 Install end-of-line resistors to electrically supervise wiring. Generally, locate end-of-line resistors at ceiling lines above a pull station location. Provide isolators and install in accordance with ULC standards. Properly label and identify. Do not locate end-of-line resistors and isolators in concealed locations. Generally install in equipment rooms.
- .8 Refer to drawing riser diagram and connection schedules. Quantities of components to be as per floor plans and not riser diagram.
- .9 Confirm exact location of components prior to roughing-in.
- .10 Ground and bond system as required by local governing electrical code and authority and system manufacturer.

3.06 SYSTEM TESTING, VERIFICATION AND CERTIFICATION

- .1 All fire alarm system modifications and new installations shall be verified in accordance with the requirements of the Ontario Fire Code. Verification in its entirety shall be witnessed by the University of Toronto's Fire Alarm Testing & Maintenance Contractor, to help to ensure the integrity of the field verification process. The contractor performing the Work shall include the cost of subcontracting this work in his bid as a separate identified price, and shall schedule the verification with University of Toronto's Fire Alarm Testing & Maintenance Contractor at least two weeks in advance of its commencement. Verification will not be accepted without a letter of witnessing from the University's Fire Alarm Testing & Maintenance Contractor. Any exceptions to this requirement shall be authorized in writing, at the discretion of University of Toronto Fire Prevention, acting in the best interests of the University.
- .2 When a relocation, addition, or deletion of a device has been carried out, all devices in the zone shall be tested and documented for proper operation. This applies to both alarm initiating and signal (output) circuits. This testing shall be witnessed as noted in the previous item, and the cost for such shall be included in the Contractor's bid.
- .3 Where fire protection and life safety systems, and systems with fire protection and life safety functions, are integrated with each other, the systems shall be tested as a whole in accordance with CAN/ULC-S1001, "Integrated Systems Testing of Fire Protection and Life Safety Systems", to verify that the systems have been properly integrated.
- .4 Submit to Consultant for approval, proposed schedule for testing and verification of system. Obtain such approvals prior to start of testing. Consultant and/or other Owner's representatives to have option to witness all or part of testing and verification work. Notify Consultant and Owner minimum 7 working days in advance of testing.

- .5 Include for fire alarm system manufacturer to inspect, test, verify and certify system components and wiring, individually and as a complete system, in accordance with requirements of CAN/ULC S537. Work to include but not be limited to provision of following:
 - .1 to ensure that type of equipment installed is that designated by Contract Documents;
 - .2 to ensure that wiring connections to equipment components show that installer observed ULC and CSA requirements;
 - .3 to ensure that equipment was installed in accordance manufacturer's recommendations, and that signalling devices of whatever manufacture were operated or tested to verify their operation;
 - .4 to ensure that supervisory wiring of those items of equipment connected to a supervised circuit is operating and that governmental regulations, if any, concerning such supervisory wiring, have been met to satisfaction of inspecting officials;
 - .5 to ensure that sequence of operation is in accordance with existing sequence of operation and any modifications identified on documents and are approved by local fire authority;
 - .6 to ensure that devices are commissioned and operable.
- .6 System manufacturer to also be responsible for but not be limited to provision of following additional work to existing systems:
 - .1 coordinate with local fire authority inspector and Electrical Division Contractor, required testing and verification work in order to obtain certification and meet local fire code and local fire authority requirements;
 - .2 test system battery power supplies and demonstrate compliance with local governing building code and local fire authority requirements that battery supplies are capable of providing required 24 hours of supervisory power followed by local governing building code required time (or time directed by local fire authority) of full load power; exact method of testing to be approved by local fire authority, Consultant and Owner; confirm exact procedures with previously named parties prior to testing; include for sufficient sound measurement devices and personnel in order to successfully comply with this requirement;
 - .3 full review, testing, and verification of operation of building ventilation and smoke exhaust system and its integrated operation with fire alarm system and various pieces of air handling equipment;
 - .4 full review, testing and verification of operation of integrated systems such as elevators and their emergency sequence of operation, supervisory annunciation of sprinkler/standpipe monitor switches, pressure switches and flow switches, diesel genset alarms, security alarms, BAS alarms, release of door holders and electromagnetic locks, and any other integrated components; coordinate requirements with trades responsible for integrated components and systems who will be present at time of testing and verification work;

- .5 test that system audible devices provide alarm sound levels in areas as per local governing building code and local fire authority requirements; site adjust tap settings of audible devices as required to achieve required audibility levels; also test that emergency voice communication system meets or exceeds intelligibility requirements of local governing building code and is approved by local fire authority;
- .6 coordination with Electrical Divisions and local fire authority to provide requirements to obtain certificates of approvals from local fire authority;
- .7 provide full detailed test sheets of tested components and provide certification that system work has been fully tested, that devices have passed testing and that system is in proper work order in compliance to local governing code requirements and project documents; testing report documents to be additionally provided in electronic format as confirmed with Owner and Consultant.
- .7 Contact local fire authority inspector and coordinate and arrange for Fire Inspector to perform required inspections. Integrate local fire authority inspection requirements with testing and verification work to extent as per Fire Inspector's directions. Obtain full approval and certification by local fire authority.
- .8 Local fire authority inspector, Consultant and Commissioning Agent to at their discretion test system or parts of system in their review of test reports. Correct/repair any failures or deficiencies found in system, whether or not identified in test reports of manufacturer. Re-test and re-verify until successfully passed, at no extra cost to Owner.
- .9 Obtain from local fire authority required certificate of approval of system and forward to Consultant.
- .10 Arrange for manufacturers to supply reasonable amounts of technical assistance with respect to any changes required to conform to paragraphs above. During period of inspection, testing and verification, make Electricians available to do any required correction work and to assist during this Work. Include for trades responsible for integrated components (i.e. exhaust fans, sprinklers, elevators, gensets, etc.) and systems to be present at time of testing and verification work.
- .11 On completion of verification, inspection and testing of system, obtain from manufacturer and forward to Consultant, a verification certificate together with detailed inspection reports listing each and every system component, its location in building and its acceptability. Verification certificate and inspection reports to be prepared and signed by certified testing technicians of manufacturer. Signed test reports to confirm that systems are installed and perform in accordance with requirements specified above.
- .12 Obtain from system manufacturer and testing agency and forward to Consultant a certificate of liability insurance of minimum amount of Two Million Dollars (\$2,000,000.00) that is to be registered for this project to show satisfactory proof of manufacturer's liability coverage for both their product and personnel.
- .13 Unless approved in writing by Consultant and Owner, do not use open flame and/or smoke for testing.
- .14 Testing technician to be certified and approved for fire alarm system testing by Canadian Fire Alarm Association (CFAA) and local Fire Marshall, as applicable.
- .15 Refer to 3.04.3 in this Section for requirements of an Integrated Systems Testing.

- .16 Additionally, refer to testing, coordination and verification requirements in Section entitled Electrical Work Analysis and Testing and include applicable requirements.

3.07 MONITORING OF SYSTEMS

- .1 In areas that remain occupied and used by Owner during Work, daily monitor and supervise existing fire alarm system serving renovation/working areas. Ensure that 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, system to ensure that it is in proper working condition;
 - .2 if portions of system are not in proper working order, provide temporary bypass wiring (if fire alarm system, must be subject to approval of local fire authority), and/or provide supervisory personnel to monitor systems for area affected;
 - .3 document and sign off with Owner's representative signing off also, each respective daily check condition;
 - .4 ensure that work to system does not affect portion of system serving areas outside of renovation/working areas.

3.08 AS-BUILT DRAWINGS

- .1 A complete set of as-built drawings shall be compiled and submitted to U of T Fire Prevention, showing locations of all fire alarm devices, conduits, junction boxes, and end of line devices. Drawings shall identify numbers of conductors and zones served, as well as device addresses for addressable systems. The installation will not be accepted until this documentation has been received in full.

END OF SECTION

1 General

1.1 **SECTION INCLUDES**

- .1 Labour, Products, equipment and services necessary for earthwork work in accordance with the Contract Documents.

1.2 **REFERENCES**

- .1 ASTM D698, Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort.
- .2 ASTM D4253, Test Method for Maximum Index Density and Unit Weight of Soil Using a Vibratory Table.
- .3 CAN/CSA A23.1/A23.2-M, Concrete Materials and Methods of Concrete Construction/Methods of Tests For Concrete.
- .4 OPSS, Ontario Provincial Standard Specification.

1.3 **SUBMITTALS**

- .1 Reports:
 - .1 Submit written laboratory test reports.
 - .2 Submit written field inspection and test report results after each inspection.
- .2 Submit dewatering methods 30 days in advance for review by Consultant. If well point system is required, Engineer shall design system and supervise installation.
- .3 Submit to Consultant details of locations where surplus soils and other materials are to be disposed of or reused. Include each disposal/reuse Site and type of surplus soil or other material, location of the disposal/reuse Site, operator's name and business address, type of license under which Site operates, and criteria used by Site to access suitability of surplus material for disposal.
- .4 Submit to Consultant, within 48 hours of a load of surplus soil or other material leaving the Site, a daily register recording the time and place of disposal/reuse of each load signed by a representative of the disposal site. Such documentation must be submitted before payment for excavation will be made.

1.4 **QUALITY ASSURANCE**

- .1 Have shop drawings signed and sealed by a Professional Engineer licensed in Province of Ontario and having experience in design and inspection of shoring, bracing, underpinning and dewatering (if required) required to complete Work.
- .2 Manage on-Site and excess soil in accordance with authorities having jurisdiction.

1.5 SITE CONDITIONS

- .1 Cultural heritage resources: If Cultural Heritage Resources (such as archaeological sites, artifacts, building and structural remains, and/or human burials) are encountered during performance of Work, contact Consultant immediately and suspend Work in immediate area until assessment has been completed by Ministry of Culture, Tourism and Recreation. Perform required measures to mitigate negative impacts on found resources to acceptance of Consultant.

1.6 PROTECTION

- .1 Existing buried utilities and structures:
 - .1 Size, depth and location of known existing utilities and structures are indicated for guidance only. Completeness and accuracy is not guaranteed.
 - .2 Prior to commencing any excavation Work, have authorities stake out utility locations to prevent disturbance during Work.
 - .3 Confirm locations of buried utilities by careful test excavations. Hand dig test excavations as necessary.
 - .4 Maintain and protect from damage, water, sewer, gas, electric, telephone and other utilities and structures encountered. Obtain permission of Consultant before moving or otherwise disturbing utilities or structures.
- .2 Existing buildings and surface features:
 - .1 Conduct with Consultant, a condition survey of existing buildings which may be affected by Work.
 - .2 Protect existing building which may be affected by Work from damage while Work is in progress and repair damage resulting from Work.
 - .3 Confirm with Consultant, condition Survey of buildings and structures undertaken by Consultant.
- .3 Temporarily cover local existing maintenance holes to prevent entry of earth or debris. Ensure adequate surface drainage in affected area is maintained.
- .4 Protect Work or work of other Contracts in progress or completed and protect existing properties, stored Products, services, and utilities from damage.
- .5 Protect excavations against flooding and damage and install and maintain appropriate warning devices during construction and during time when Work is closed down for any cause.
- .6 Protect bottom of excavations that will support foundations, slabs, pavements etc. from frost or freezing.
- .7 Keep access roads clear of debris and dirt resulting from Work of this Section to acceptance of Authorities having jurisdiction.

- .8 Shoring, bracing and underpinning: Comply with local regulations, authorities having jurisdictions and requirements specified.

2 Products

2.1 **MATERIALS**

- .1 Materials, general: Aggregate materials to provide minimum soil bearing capacity of 25 kPa as shown on Structural Drawings.
- .2 Select fill: Subject to approval of Consultant consisting of reusable fill excavated from Site or imported fill that is free of organic matter, rubble and material other than soil. Maximum particle size of half thickness of lift specified, moisture content at time of placing 2% maximum over its optimum moisture content and is either non plastic or has a plasticity index of 25% maximum.
- .3 Granular A fill: Imported Granular A fill, free of organic matter and, in accordance with OPSS 1010.
- .4 Granular B Fill: Imported Granular B fill free of organic matter and in accordance with OPSS 1010.
- .5 Clear stone fill: 19 mm clear stone in accordance with OPSS 1004, free of organic material.
- .6 Unshrinkable fill: 0.7 MPa cement stabilized backfill conforming to requirements of CAN/CSA A23.1/A23.2-M.

3 Execution

3.1 **EXAMINATION**

- .1 Verify condition and dimensions of previously installed work upon which this Section depends. Report defects to Consultant. Commencement of Work means acceptance of existing conditions.

3.2 **LINES AND ELEVATIONS**

- .1 Establish lines and elevations from Control Points shown on Contract Drawings.
- .2 Have lines and elevations established by Registered Ontario Land Surveyor or qualified Civil Engineer registered in Province of Ontario.
- .3 Protect and maintain Control Points and Bench Marks as long as they are required.

3.3 REMOVAL OF WATER

- .1 Obtain letter of conditional approval from authorities having jurisdiction to dispose of ground water into sewer drainage system. Apply for and pay for water disposal permit.
- .2 Keep excavations and trenches free of water throughout construction period.
- .3 Groundwater removal:
 - .1 Lower groundwater level and maintain at depth below lowest point of excavation to ensure a dry stable surface.
 - .2 Dewater to prevent loss of soil and maintain stability of sides and bottom of excavation and of adjacent structures.
 - .3 Dispose of water in conformance with applicable by-laws and in a manner not detrimental to public and private property, or portion of Work completed or under construction.
 - .4 Supply and install settling basins, or other treatment facilities to remove suspended solids or other materials before discharging to sewers, water courses or drainage areas in accordance with authorities having jurisdiction. Perform testing on settlement tank discharge to confirm that effluent meets sewer bylaw requirements. Locate tanks to acceptable area determined by Consultant.
 - .5 Should method of dewatering fail to achieve conditions specified above, Consultant reserves right to revise methods and procedures at no cost to Owner.
- .4 Do not obstruct flow of surface drainage or natural water courses.

3.4 EXCAVATION

- .1 Remove concrete, masonry, paving, demolished foundations and rubble and other obstructions encountered during excavation Work.
- .2 Excavate to required lines and grades shown on Contract Drawings with allowance for subsequent Work including shoring, bracing and formwork. Make excavation clean and clear of loose material and true to size.
- .3 Protect stockpiles of fill against contamination and moisture absorption.
- .4 Do not undermine adjacent structures. Where it is necessary to have footings at different levels, found upper footing below imaginary 10-horizontal-to-7 vertical line, or as otherwise indicated, drawn up from base of lower footing. Protect adjacent foundations from frost.
- .5 Have excavations in excess of 1200 mm in depth conform to requirements of Occupational Health and Safety Act, and Regulations for Construction Projects.

- .6 Do not expose shale at subgrade elevation to drying cycles and in any case, following inspection, cover with minimum 50 mm of lean concrete within 4 hours after exposure.
- .7 Fill excavations for foundations which are, through error, carried below elevation shown or approved depth, with 15 MPa concrete, or as directed by Consultant.
- .8 Trim, and remove loose material, debris and organic material from excavations. Where material at bottom of excavation is disturbed, remove disturbed material and re-compact to density equal to or better than undisturbed soil or backfill with lean concrete as directed by Consultant.
- .9 When excavations are complete, prior to commencement of subsequent Work, request Consultant for inspection of excavation Work.

3.5 **EXCAVATED MATERIAL DISPOSAL**

- .1 Except for material to be used as select fill, immediately remove and dispose of excavated material from Site.
- .2 Remove and dispose of construction rubble, abandoned gas, water and sewer pipes, valves, valve boxes and fittings, maintenance holes, frames and covers and other material which may be encountered during excavation but not indicated on Contract Drawings.

3.6 **BACKFILLING**

- .1 Do not proceed with backfilling operations until walls, slabs, waterproofing and below grade Work has been inspected and accepted by Consultant.
- .2 Backfill areas which are free from debris, snow, ice, water and frozen ground.
- .3 Do not use backfill material which is frozen or contains ice, snow or debris.
- .4 Do not backfill on or against any membrane or protection board covered waterproofing with jagged rock or other sharp objects which might damage waterproofing.
- .5 Limit vertical drop of backfill material to 2000 mm.
- .6 To avoid pockets and voids, remove sheathing and shoring materials that require removal, as backfilling progresses.

- .7 Prior to backfilling or placing concrete on exposed soil subgrade, proof roll subgrade to identify soft or loose areas. Proceed with placing backfill or concrete only after inconsistencies identified by above procedure have been reworked and compacted or excavated, backfilled and compacted as required to eliminate such conditions to acceptance of Consultant.
- .8 Place backfill material, grade and compact to levels shown on Contract Drawings.
- .9 Place backfill materials in uniform layers 200 mm maximum loose thickness unless specified otherwise.
- .10 Ensure each layer is compacted, and accepted by Consultant, before placing succeeding layers.
- .11 Where there is a common boundary between select fill and granular fill or unshrinkable fill, place select fill after granular fill has been compacted. Place and compact fill around free standing structures evenly on all sides of structure simultaneously in layers sloping away from structure.
- .12 During backfilling, take care to avoid displacing or damaging Utilities Work and Services.
- .13 Notify Consultant prior to commencement of backfilling and compacting operations.

3.7 **COMPACTION**

- .1 Compaction densities for granular fill materials will be determined by ASTM D698. Compaction densities for clear stone will be determined by ASTM D4253.
- .2 Add water if necessary to obtain required densities. Correct irregularities or depressions that may develop during compaction by removing or adding material to form a smooth and uniform surface.
- .3 Shape and roll alternately to obtain smooth, even and uniformly compacted base.
- .4 If material is excessively moist, aerate by scarifying with suitable equipment until moisture content is corrected.
- .5 In areas not accessible to rolling equipment, compact to specified density with mechanical tampers acceptable to Consultant.
- .6 Compact backfill materials providing the following as a minimum:
 - .1 Under slabs, walks and pavements: 100% (SPMDD).
 - .2 All other areas: 95% (SPMDD).

3.8 GRADING

- .1 Prior to placing fill over existing ground, scarify surface to depth of 150 mm. Maintain fill and existing surface at approximately same moisture content to facilitate bonding.
- .2 Place material only on clean unfrozen surface, properly shaped and compacted and free from snow and ice. Ensure no frozen material is used in placing.
- .3 Grade as necessary to bring Work areas to required elevations. Supply additional material required to obtain new grade levels. Place and compact as specified.
- .4 Grade materials using methods which do not lead to segregation or degradation of aggregate.
- .5 Shape each layer to smooth contour and compact to specified density before succeeding layer is placed.
- .6 Remove and replace that portion of layer in which material becomes segregated during spreading.
- .7 Make graded areas smooth to profile, free of debris, with local excavations and depressions filled and compacted.

3.9 UNSHRINKABLE FILL

- .1 Place unshrinkable fill in locations indicated on Contract Drawings or where Work area is too limited to permit proper placing and compaction. Obtain Consultants approval prior to placing unshrinkable fill. Place in accordance with supplier's written instructions.
- .2 If embedded items occur in area being backfilled, coordinate with appropriate trades to ensure that disturbance of embedded items during backfilling is prevented.

3.10 RESTORATION

- .1 Upon completion of Work, remove surplus materials and debris and correct defects as directed by Consultant.
- .2 Clean and reinstate areas affected to acceptance of Consultant.

END OF SECTION